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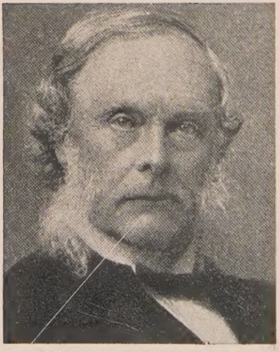
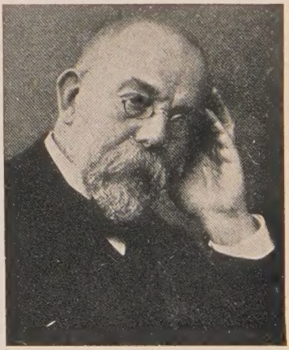
Antonj van Leeuwenhoek (1632–1723).

Edward Jenner (1749–1823).

Louis Pasteur (1822–95).



Lord Lister (1827–1912).



Robert Koch (1843–1910). (Courtesy of Captain Henry J. Nichols, U. S. Army.)

BACTERIOLOGY
FOR NURSES

By

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and

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INTRODUCTION

With the advance in all branches of science, our knowledge of disease, its transmission, cause, effects and cure has kept pace. More and more is demanded of the medical student, the physician and especially of the nurse. The nurse of today knows as much, or more of these things, at the end of her training, than the most learned scientists of a half or three-quarters of a century ago. It is desirable and necessary that she should. Standards of excellence have been raised both in practical procedure and in theoretical training. We have acquired knowledge and should make what use of it we can.

The present edition of this text-book contains information which it is believed desirable all up-to-date nurses should have. Not all of the material included in the book will be used by every instructor, and it is inevitable also, that some instructors will desire material which is not included. The material which has been selected has been so arranged that the instructor may select that which is needed.

The new edition is divided into three sections. The first deals with general and basic principles; Biology; the cell; constitution of the blood; immunity; transmission of disease, etc. The second section deals with the bacteria themselves and the diseases they cause. The third section is an advance in accord with the

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growing importance of Public Health and Preventive Medicine. It deals with the prevention of disease.

Several new chapters have been included. There is a new discussion of filterable virus diseases, molds, yeasts, anaerobic bacteria, scarlet fever, protozoa, anthrax, pertussis, sanitation and rules for nurses, venereal diseases, immunity and infection and other important topics. Every chapter has been carefully revised or rewritten and new material has been added on practically every page.

The presentation of the material has been kept as untechnical as possible. The use of some technical terms is not wholly undesirable provided the meaning is made clear either in the text or the glossary which is included in the appendix. The nurse is confronted sooner or later with technical terms, and it is as well she should become familiar with the common ones early.

Detailed descriptions of laboratory procedures have been restricted to two or three staining methods and one or two other things of minor importance. The directions for staining and the use of the microscope are largely for the convenience of instructors. Much talking is thus avoided since reference can be made to "the book."

The illustrations of bacteria have been made from drawings and are in color. There are several advantages in this. They are all made on the same scale of magnification. Most of the drawings are composite pictures and show several forms of the same organism. They illustrate the salient points more diagramatically than photographs and being more or less diagramatic are intended to convey more information than photographs. They also show the staining characteristics.

The section on experiments and demonstrations is intended to be suggestive to the instructor. The exercises may, of course, be made more elementary or more advanced, or otherwise modified to meet the needs of the students. A number of the experiments have been adapted from the course in bacteriology for nurses given at Simmons College, others from the course given at the Johns Hopkins Training School. For class purposes the instructor should make use of cultures which come into the hospital laboratory and should explain their clinical bearings. To see both the patient and the culture helps the nurse to integrate her ward- and classwork and makes bacteriology of immediate and practical interest to her.

A good deal of stress has been laid on the transmission of disease. Many points on transmission, especially as related to the nurse, are repeated, restated and emphasized. This is believed desirable. It is one of the most important things a nurse, has to learn. A good knowledge of the fundamental facts in the transmission of infection of all sorts will go a long way toward making a useful, safe and reliable nurse.

MARY ELIZABETH MORSE.
MARTIN FROBISHER, JR.

BALTIMORE, MARYLAND.
May, 1928.

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Bacteriology for Nurses

SECTION I

General Bacteriology

CHAPTER I

INTRODUCTORY

Biology.—Before plunging into a detailed study of the bacteria, it may be well for us to discuss the nature of living things in general. The nature of life itself is still entirely a mystery—but we are able at least to study the form and structure and activity of living things. This study constitutes the science known as *Biology*, and *Bacteriology is one branch of Biology.*

All living matter is composed of a substance called protoplasm. This substance is usually rather watery in character—transparent—usually colorless—and in general very much like raw white of egg, which is itself protoplasm. Protoplasm, when analyzed in the laboratory, is found to consist largely of the elementary substances called carbon (soot is one form of carbon), oxygen (a gas present in the air we breathe and necessary to life), hydrogen (a gas not present in the air but usually combined with oxygen to form water and other substances), and nitrogen (a gas present in the air).

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Just how and in what way these elements, as they are called (from their simplicity of structure), are combined to form protoplasm, no one knows exactly. If we did know, it might be possible for us to create living matter. *Nitrogen must, however, always be present for the formation of protoplasm.* This important fact will be discussed later when we come to consider the relationships between different forms of living creatures found on the earth. It is sufficient to say at present that the nitrogen, in the form in which it exists in the air, cannot be used by living creatures until it is combined chemically with some other substance—usually oxygen. It is the function of certain bacteria to bring about this highly important combination.

The Cell.—It might be imagined that if all living things were composed of a watery substance, they would soon collapse, drain away and dry up. How do living things maintain their shape and continue to keep from being dissolved by the rains? It was discovered long ago by Schleiden and Schwann, two German scientists (1838), that the protoplasm of all living things is contained in tiny subdivisions or chambers which are called *cells*. Each cell is extremely minute, and it takes millions of them together to form so large a creature as a tadpole. It was also found that the protoplasm of each cell is differentiated into at least two special portions. First, part of the protoplasm is thicker and more membrane-like at the outer boundary and thus forms a retaining *wall* which holds the cell contents. Another portion of the protoplasm is condensed into a rather solid little globule near the center which is called the *nucleus*. The nucleus takes upon itself all of the vital properties. It seems to be the essential part of the cell, for without a nucleus a cell soon dies. The nucleus may, however, live by itself for some time. Indeed, there are some cells which seem to consist almost entirely of nuclear material. (See Fig. 1.)

Cells differ greatly according to the kind of animal or plant they are part of, and according to the particular organ of the body they go to make up.

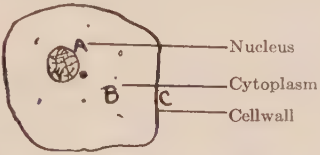

FIG. 1.—Diagram of a cell, showing essential parts. The entire cell is composed of *protoplasm*. Many cells are much more complicated than this one.

Organs and Tissues.—It is easy to see that there must be many different sorts of cells in a being like man. There is the group of cells which go to make up the liver, for example, and the group of cells which compose the eyes, those which compose the skin, the brain and so on. A group of cells of the same kind, which have the same shape, constitution and function in the body, is called a *tissue*. The liver, spleen, muscle, etc., examples of *organs*, each being composed of special sorts of tissues.

Single-celled Organisms.—It must not be imagined that *all* beings consist of millions of cells. There are creatures so lowly that they consist of only one cell. Their life must indeed be very simple and devoid alike of pain and pleasure. They are spoken of as single-celled or unicellular plants (or animals, as the case may be). Their entire life work consists in feeding, breathing, excreting waste products and multiplying in numbers. Since they have only a cell membrane, a nucleus and the bit of remaining protoplasm spoken of as *cytoplasm,* (cyto: Greek for cell; plasm: Greek for substance) it may seem strange that they are able to do even as much as eat and breathe. But this they do. In the first place, with the exception of only one or two classes of cells, their food must be in solution, that is, dissolved in water. In this form, when they are bathed in a solution such as blood or beef broth, the substances which they use as food simply soak into them through the cell wall. Waste products in turn soak outward. Soon the cells are surrounded by a mixture of food substances and waste products—all in solution. The cell wall seems to be permeable to just the right substances. It allows only waste products and certain other substances to pass outward, and only food substances to pass inward. Oxygen also, small amounts of which are always found dissolved in water, usually passes through the membrane. The process is all passive. The cell simply absorbs its food. The processes by which the waste products and other substances pass outward are called diffusion and excretion or secretion. Different cells secrete different substances in addition to their waste products.

As for the **multiplication of cells**—it is very simple. There are no sexes. A cell, when it becomes mature, simply splits in two. Each half receives half of the cell wall, half of the nucleus and half of the cytoplasm and any other special parts of the protoplasm which may be present in that particular sort of cell. The two cells are called daughter cells. They in turn mature and split and so the process goes on as long as nitrogen-containing food is present, waste products do not accumulate too much, and there are enough oxygen and water and other necessary materials.

Such processes take place in the unicellular forms of life as well as among the cells in the large multicellular forms. All that is necessary for the unicellular forms is to find suitable fluids in which to live. In nature there is much fluid matter where unicellular organisms may thrive. There are rivers, lakes, sewage, decaying animals, and so on. The cells of multicellular forms are provided with, and constantly bathed in, special fluids. In animals this is the blood and lymph. In plants it is the sap. In practically every case the food of the cell must be in liquid form.

Enzymes.—Cells very often have the power of changing solid food substances into liquids and thus availing themselves of additional sources of nourishment. They do this by means of certain special secretions. The nature of these secretions is rather obscure, but we know that they exist and that they can bring about the most remarkable changes in a great variety of substances. Such secretions are called *enzymes*. There are enzymes which can so change gelatine that it becomes permanently liquid and will no longer "set." Other enzymes can change sugar into alcohol and a gas called carbon dioxide. Common baker's yeast gives off an enzyme which does this and the process is used in making wine and bread. There are thousands of different enzymes. The cells which line our own stomachs and intestines produce enzymes which transform bread and meat into material for our blood and bone. Not all cells produce all enzymes. Most cells produce only one, two or three.

Some of the enzymes, or enzyme-like substances, which certain bacteria produce are very poisonous (or *toxic*, as it is called) and produce disease.

Bacteria which produce disease in any manner are spoken of as *pathogenic* (patho = disease; genic = producing). However, not all pathogenic bacteria are pathogenic because of their enzyme or toxin (poison) secretion. Some are pathogenic because they are composed of protoplasm which is, in itself, poisonous to us, very much as some toadstools (which are plants just as bacteria are but consist of many cells instead of one) are composed of very poisonous matter.

The Constitution of the Blood.—Before leaving the discussion of cells and tissues in general, it may be well to include a brief description of one of the most important fluids in all medicine and biology, and one of which we shall have much to say later on, namely, the blood.

Human blood consists of four essential constituents. They are, first, the fluid portion known as *plasma*. This is a yellowish, transparent fluid, consisting of a solution of proteins and other soluble substances, food for, and waste products of, the body cells. In the plasma are red corpuscles and white or colorless corpuscles. The red corpuscles (erythrocytes) (erythro = red; cyte = cell) are cells which are formed in the spleen, liver and bone-marrow and float in the plasma. The red color of the blood is due to the hemoglobin which they contain. They have no nucleus and hence probably are not very long-lived but are constantly being replaced. They carry oxygen from the lungs to all parts of the body and thus the innermost cells of the body breathe. They number about 15,000,000 to the drop (5,000,000 per cubic millimetre).

The *white corpuscles* (leucocytes) (leuco = white; cyte = cell) are much larger and less numerous than the red ones. There are only about 7,000 per cubic millimeter. They have a very important function in acting as scavengers and policemen in the blood. Any foreign particles, such as dead cells, bacteria, dirt and so on finding their way into the blood or into wounds, etc., are promptly disposed of by the white cells. White cells have the power of eating solid particles. This they do by engulfing them with their whole body. The particle passes through the cell wall into the interior of the cell. It may be liquified there by digestive enzymes inside the cell. Leucocytes are able to move out of the blood vessels and travel about

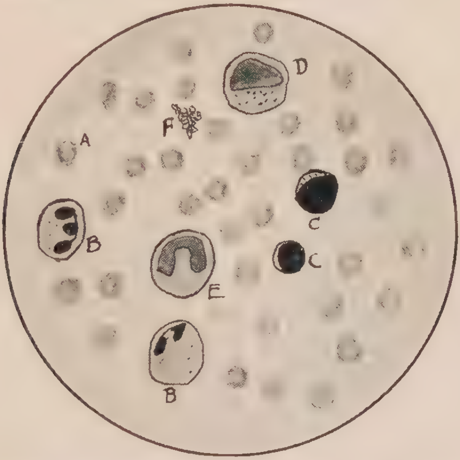

Fig. 2.—Stained smear of normal human blood showing different kinds of corpuscles. A, Red corpuscles (erythrocytes); B, white corpuscles (polymorphonucleated leucocytes); C, small lymphocytes. (These are another kind of leucocyte); D and E, other kinds of leucocyte. (Large lymphocytes.) F, Blood platelets. Magnified 600 times.

through the tissues. When some undesirable particles (as bacteria in a boil) set up inflammation, the leucocytes are attracted to the spot and congregate there sometimes in enormous numbers. They endeavor to dispose of the foreign particles by eating or engulfing them. Usually many of the leucocytes die in the process. The white, creamy material in a boil or other infected spot consists largely of these dead leucocytes, dead bacteria and some of the tissue cells and blood serum all mixed up together. This material is called *pus*. The dead leucocytes are called *pus cells*.

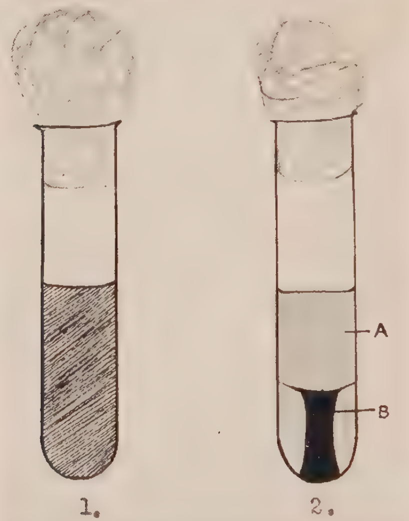

Fig. 3.—Tube No. 1 shows whole blood before clotting. Tube No. 2 shows the contracted clot at "B" and the transparent serum at "A." Note that the clot appears very dense due to the fact that it has enmeshed all the blood corpuscles.

The process will be discussed later on under the heading "Inflammation." (See Fig. 2.)

Besides the red and white corpuscles, the plasma contains the material which makes blood *clot* when it gets outside the body. The clot, when it forms, is made up of *fibrin*. Inside the body certain substances in the plasma keep the blood in fluid condition. Once the blood escapes, however, it is changed and the clot forms. Now the fibrin is rather elastic and clots shrink as they form. The fibrin, as it shrinks, pulls the red and white cells with it and the fluid portion of the blood, not being able to shrink, is squeezed out of the clot (very much as water would be squeezed out of a rapidly shrinking sponge) and appears as a clear, pearly gray or straw-colored fluid called *serum*. Serum contains all the soluble parts of the blood. It is really nothing but the plasma deprived of its red and white cells and its fibrin. It is used widely in the study of disease. We shall have more to say of blood and serum later on. (See Fig. 3.)

CHAPTER II

THE BACTERIA. THEIR DISTRIBUTION AND ACTIVITIES

Having now some idea of what the life processes of living cells are, let us turn our attention more especially to those simple, single cells, the bacteria. Bacteria are unicellular plants. They were probably among the very early forms of life to appear on the earth. It is probable that they helped prepare the earth for the further development of plants and animals.

Bacteria, however, were not discovered until fairly recent times, for, because of their minuteness, a knowledge of their existence had to await the invention of the microscope. The first person who saw and described bacteria was *Antonj van Leeuwenhoek*, a Dutch investigator (see Frontispiece) who made one of the earliest microscopes. With this crude instrument he examined water from pools, the tartar from his teeth, and feces from a case of dysentery, and many other substances and fluids. He was amazed to see in all of these what he called tiny animals, round, rodlike, and spiral-shaped, some of which were in rapid motion. The drawings that he made are still in existence, and prove that what he saw actually were bacteria. This discovery of van Leeuwenhoek's in 1683 opened up a new world—that of the extremely small. The importance of his observations was not appreciated, however, and it was about a hundred and fifty years before much advance was made in the investigation of bacteria.

Following the discovery of bacteria, the idea gradually grew up that they were the cause of disease, but this could not be proved until methods of growing organisms in pure culture in the laboratory had been worked out. This was largely the work of two men: *Louis Pasteur*, a French scientist, and *Robert Koch*, a German physician. (See Frontispiece.) Shortly after the middle of the last century Pasteur proved that fermentation and putrefaction were caused by organisms, and about 1880 Koch introduced the general methods of growing bacteria in cultures which are still in use today. *Lister*, an English surgeon, applied Pasteur's discoveries to surgery even before the actual bacteria which cause infections had been discovered. The work of Pasteur and Koch was the beginning of the science of bacteriology, and it opened up a new world to medicine. Within the fifteen years following 1880 the organisms causing the majority of infectious diseases had been discovered. Before the days of bacteriology infection was an unseen and mysterious enemy which it was impossible to control; it was "the pestilence which walketh in darkness." Now we know what it is, how to deal with it intelligently, how to prevent and control it.

It is easy to see why a microscope is necessary for the discovery and study of bacteria when we realize that the largest bacteria are only about $1/500$ of an inch long. The common bacteria of the intestine are only about $\frac{1}{10,000}$ of an inch long. Nearly 2 billion (2,000,000,000) of medium sized bacteria may easily be contained in a single drop of water, and about 30,000,000,000 would hardly weigh as much as a ten cent piece. There is proof, also, that there are organisms which are much smaller than this and cannot be seen even with the strongest microscopes.

The Work of Bacteria in the Outside World.—Persons whose work lies constantly with disease, as doctors and nurses, are inclined to have a one-sided view of bacteria. They may think of them all as evil and as enemies of human life; whereas comparatively few kinds cause disease. The greater number are harmless to man, and the work of most bacteria is good and, in fact, necessary to human life. Bacteria may, therefore, be divided into two great groups according to their activities: the harmful and the useful. The first kind live on or in the bodies of human beings and cause disease. These are spoken of as *pathogenic.* The second kind have their home in the outside world and are harmless to man. These are spoken of as *saprophytic,* unless they be pathogenic for plants or animals. Out of more than two thousand known kinds of bacteria, less than one hundred injure any one.

Many of the pathogenic bacteria can live only in the body and find the outside world cold, dry, and unfriendly, and soon die if they are cast forth into it. On the other hand, the human body is too warm and other conditions are unsuitable for those which are adapted to life outside, so that they do not multiply there.

Before studying the disease-producing bacteria, with which medicine and public health are chiefly concerned, we should get a wider view of the activities of bacteria and their place and importance in the world. So we will take up first the useful bacteria, the work of which we see all about us.

The useful bacteria carry on a multitude of tasks in nature and bring about changes which are necessary for the existence of animals and man. One of their most important activities is the decomposition of dead animal and vegetable matter, a process which we know as decay or putrefaction.

We usually think of putrefaction as an unclean, disgusting process, as it certainly is in some relations, but it is really nature's way of purifying the earth. The complicated materials of the plant or the animal body are decomposed after death into water, gases, and simple substances that plants can use for food. For instance, when a dead animal is buried in the ground, bacteria from the soil, and those already in the animal's intestine, skin, etc., enter the body and cause it to disintegrate. The gases and water that are formed pass off into the earth, and other substances which the bacteria produce from the animal's body contain combined nitrogen and are suitable food for plants. In this way the dead animal body disappears, and the materials of which it was made up are used over again to nourish plants. Animals use the plants for food, and after their death they in turn are changed into food for plants; for it is one of the great laws of nature that no particle of matter shall be lost or wasted, but only changed into other forms. It is through the work of bacteria that the accumulation of dead animal and vegetable matter is prevented and the earth kept fit for living things. Without their activity life would be impossible. This cycle of changes (Fig. 4) in which bacteria are the connecting link between death and life, is one of the most marvelous and beautiful provisions in nature. Practically all of the changes involved in decomposition are brought about by the enzymes secreted by the bacteria.

The conditions most favorable for putrefaction are therefore those which are most suitable for the growth of bacteria. A moderately warm temperature, about that of hot summer weather, is best. Moisture is also necessary, for, as every one knows, no perfectly dry substance ever decays. We all know how quickly things decay or spoil in hot, damp weather. The process goes on best in the dark, and can be decreased or even stopped by sunlight.

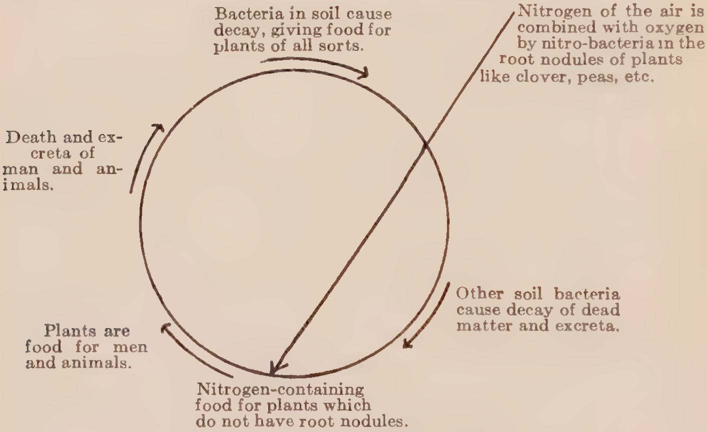
Bacteria in soil cause decay, giving food for plants of all sorts.
Nitrogen of the air is combined with oxygen by nitro-bacteria in the root nodules of plants like clover, peas, etc.
Death and excreta of man and animals.
Other soil bacteria cause decay of dead matter and excreta.
Plants are food for men and animals.
Nitrogen-containing food for plants which do not have root nodules.

Fig. 4.—The nitrogen cycle.

The wastes of man and animals (feces and urine) are disposed of by bacteria in the same way as dead animal and vegetable matter. If put on or in the soil, all traces of them soon disappear. When the farmer spreads manure on land, it is changed by bacteria into substances which plants can use for growth. The soil is thus enriched and made more fertile.

Bacteria also purify sewage. People can live in large communities only when there is some way of taking care of their wastes. Great epidemics have been caused in the past by the accumulation of filth in cities. Some of the plagues and pestilences which we read of in ancient and medieval history were undoubtedly due to this cause. Now the activities of bacteria are made use of in purifying sewage. The bacteria live on the impurities of the sewage and turn them into harmless, inoffensive substances which are food for plants. In the privy and cesspool this work is accomplished by the soil bacteria, as the contents slowly soak into the earth. In the sewage purification plants of cities the process is controlled scientifically. A much-used method for purifying the sewage of cities is to let it filter slowly through large beds of gravel. It seems almost incredible, yet foul-smelling sewage, when allowed to drain slowly down through a layer of gravel four feet deep, comes out at the bottom almost as clear as water. It is the bacteria in the gravel which work this wonderful change.

The soil bacteria also purify water in the same way as they do sewage. They take the impurities out of it as it works its way slowly through the ground, so that water which was contaminated when it entered the earth may come out pure in a well or spring. All well and spring waters are not necessarily safe to drink, however. We shall discuss the reason for this later on.

Bacteria Which Produce Food for Plants.—We have been speaking, up to this point, of the work of bacteria in decomposing complicated substances, either dead plants and animals or the wastes of animals and man, into simple substances which can be used as food by plants. It was mentioned in the first chapter that the nitrogen of the air is not in a form available for living beings, but that certain bacteria are able to combine it with oxygen and other substances so that it becomes available for plant food. These bacteria live in the soil. The little nodules on the roots of such plants as clover, beans, peas, alfalfa, etc., contain multitudes of these bacteria which have the power of taking nitrogen out of the air and combining it into substances which are essential for the growth of plants. The great store of nitrogen in the air would be useless for the needs of living things if it were not for these bacteria. (See Figs. 5 and 6.)

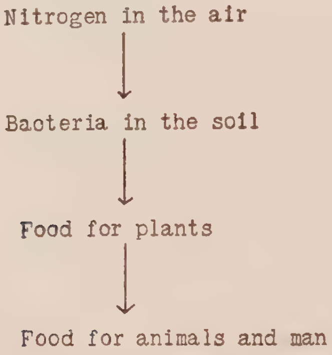

FIG. 5.—Bacteria make the supply of nitrogen in the air available for the nourishment of plants, and therefore of animals and man.

Below a depth of four feet bacteria become less numerous; and at a depth of ten or twelve feet there are usually none. The activities of the soil bacteria cease in winter.

Not all bacteria in the outside world, are friendly to plants, for plants have their infectious diseases, caused by organisms, just as much as do human beings. The blight of fruit trees, the yellow wilt of potato, tomato, squash, and melon plants are examples of plant diseases.

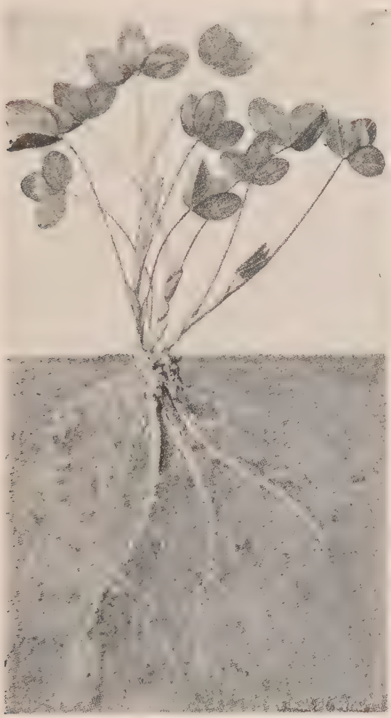

FIG. 6.—A clover plant showing the nodules on the roots which contain bacteria. These organisms can take nitrogen out of the air and build it up into substances which are necessary for the food of plants (from Arthur I. Kendall, Civilization and the Microbe).

The bacteria are carried by insects and are also washed around by rains. Only the burning of infected plants, or the affected limbs of trees, will stop the spread of the infection.

There are bacteria which live normally in water. They are sometimes present in drinking-water and are harmless, as they cannot grow in the human body. We take in considerable numbers of them every day. Water, however, which has been polluted with sewage may contain thousands or even millions to the cubic centimeter, and among them the typhoid bacillus. The water of streams, rivers, and lakes is so liable to be contaminated with sewage that it is unsafe to drink without purification. Shallow wells are also dangerous, as they frequently receive drainage from cesspools, barnyards, and sink drains. Water from deep wells is usually safe but not always. There are no simple tests which tell whether or not water is fit to drink; the only safe way is to boil all suspicious water.

The number of bacteria in the air usually depends on the amount of dust. Most of the bacteria are riding around on dust particles. They are usually of the harmless kinds and soon die in the dry air and sunlight. There are more bacteria in indoor than in outdoor air. The air of badly ventilated rooms, especially if they are not kept clean, contains many bacteria, and more when occupied, as the inhabitants stir up the dust.

Bacteria grow well in many foods. We eat large numbers of such organisms every day with no bad results. Bacteria flourish so well on some foods, such as beef broth, gelatin, potato, and milk, that these substances are used for cultivating bacteria in the laboratory. The growth of bacteria in some kinds of food is an advantage. The good flavors of cream, butter, and cheese are given by the action of certain bacteria growing in them. The variety of cheese is largely determined by the kind of micro-organisms present in it. For this reason it is customary to add "starters" (certain materials containing the desired bacteria) to cream before it is churned into butter, and to milk which is to be made into cheese.

The changes which micro-organisms bring about in carbohydrates (sugars, starches, etc.) are called fermentation. The chief substances formed are acids of different kinds, alcohol, and gases. Many different kinds of bacteria, yeasts, and molds can cause fermentation. There are different kinds of fermentation. One of the most familiar is the change of cider or wine into vinegar. The bacteria which do this collect on the surface as scum, called "mother of vinegar." The bacteria form acid from the alcohol in the cider.

Another familiar kind of fermentation is the production of alcohol from the sugar of fruit juices in the making of wine. The raising of bread is due to still another kind of fermentation. The yeast plant multiplies in the dough and decomposes a portion of the flour starch, forming gas. The bubbles of gas, imprisoned in the dough, raise the bread.

A few bacteria are sometimes present in eggs even before they are laid. Bacteria can also pass through the shell after the egg is laid. To make eggs keep longer they are often coated with a substance called "water-glass," which fills up the pores in the shell and prevents the entrance of bacteria.

The spoiling or decay of foods is caused by the growth of bacteria in them. Tainted meat, rancid butter, rotten eggs, decaying fruit and vegetables are all the result of the work of bacteria.

Distribution and Activities of Bacteria in and on Human Beings.—There are certain bacteria, as we have said before, which can grow only when in contact with the bodies of men or of animals. The healthy human body harbors millions of germs on the skin, in the mouth and in the intestine; in short, on every surface that comes in contact with the outside world or with food. Some of these bacteria are harmless and never cause disease under any conditions; but others may, under certain circumstances, gain entrance to the deeper parts of the body and cause those changes which we call an infection. Even these harmful or pathogenic bacteria may often live on the surface of the body without producing any disturbance of health. For instance, the germs causing diphtheria, tonsillitis, and pneumonia are frequently found in healthy throats, and we all carry on the skin the bacteria which are the cause of boils and abscesses. The deeper parts of the body and the internal organs may in health contain a few scattered bacteria, or they may be sterile. Each region of the body has its characteristic bacteria.

The *skin* carries large numbers of bacteria, picked up from the various things with which it comes in contact. It is impossible to make the skin absolutely sterile even with the most thorough scrubbing and the application of antiseptics. The germs in the outer layers of the skin can be removed, but it is impossible to get rid of those in the deeper layers. Therefore, rubber gloves are worn in surgical work, as they can be boiled and made absolutely sterile.

The *air* which is breathed in contains, as we have seen, particles of dust, some of which have bacteria attached. The air around persons who have been coughing or sneezing contains a germ-carrying mist of sputum, nasal secretion and saliva droplets. To demonstrate this for yourself, watch someone sneeze while sitting in the sun shining through the window of a room. It is plain that we inhale considerable numbers of bacteria daily. The inside of the nose is especially adapted for dealing with these germs. It is made up of a complicated, scroll-like arrangement of bones, covered with mucous membrane. As the air passes over these surfaces it is not only warmed and moistened, but the bacteria-laden dust sticks to the moist surfaces and is finally carried to the outside in the nasal secretion. In a healthy nose few bacteria can gain a permanent foothold, but if the passageway is stopped up by adenoids or by other obstructions, germs may find suitable conditions for growth.

The *mouth and throat* constantly contain numerous kinds of germs. Bacteria grow readily in a neglected mouth, as conditions of warmth and moisture are favorable, and bits of food around the teeth provide nourishment. Bacteria are the immediate cause of decay of the teeth. The tartar which collects around the gums is composed partly of bacteria; and the "fur" on the tongue is a mixture of bacteria, bits of food, and cast-off cells from the tongue. The mouth would contain more germs than it does if it were not for the saliva which acts as a continuous mouth wash. The bacteria are swallowed with the saliva, and many are killed by the acid gastric juice. The importance of brushing the teeth carefully and of removing bits of food from between the teeth with dental silk is apparent, and also the necessity of going regularly to the dentist. Persons who have been in contact with pneumonia or diphtheria patients may carry the germs causing these diseases in their mouths and throats, although they may not develop any symptoms.

The *stomach* normally contains few bacteria on account, as has been said, of the disinfectant action of the gastric juice; but putrefying food and large numbers of germs brought constantly to the stomach from a dirty mouth may cause digestive disturbances.

The *intestine* of the baby is sterile at birth, but bacteria enter with the first feeding.

The intestine of the adult contains enormous numbers of bacteria, and billions are thrown off every day in the feces. It has been estimated that a grown person excretes daily about 128,000,000,000 bacteria. About one-third of the solid matter of the bowel movement is composed of bacteria. In connection with these immense numbers of organisms it should be remembered that the intestine is about 26 feet long, and conditions of food, warmth, and moisture in it are ideal for bacteria. They are more abundant in the large than in the small intestine.

The *vagina* and *uterus* do not normally contain disease germs; but during childbirth bacteria may be carried in by carelessness on unsterile hands, instruments, or dressings, and cause puerperal (childbirth) fever. The uterus after childbirth is an excellent place for the growth of germs, and scrupulous care is just as necessary in obstetrics as in surgery.

CHAPTER III

CLASSIFICATION OF BACTERIA. HOW BACTERIA ARE STUDIED IN THE LABORATORY

The classification of bacteria is a very difficult and complicated problem. There are so many kinds, and their relationship to one another is so obscure that one is often at a loss to know into what group to put a new kind. A bacteriologist with a new kind of germ is in somewhat the same position as a postal clerk with a letter. The postal clerk first finds what country the letter is directed to and puts it into the group of letters going to that country. Then the letter is classified as to the state or province and is removed to the proper group. Then the city is determined, the street, the house, and finally the individual to whom the letter is directed.

Now a bacteriologist has to find out for himself in just what classification and group his organism is to be included. He proceeds first of all to examine the shape of the germ. This at once puts it in one of the three great groups into which bacteria are divided, for convenience, according to their shape. He next determines how the germ acts when treated with certain aniline (coal tar) dyes. These dyes are similar to those used for coloring dresses, fabrics, etc. This still further classifies his organism. His further procedures depend on the result of the first examinations and will be discussed after we have described the shapes and staining reactions of bacteria.

Morphological Classification.—Bacteria are divided into three groups, according to their morphology (shape); (1) *Cocci* (singular-coccus; from the Greek word for berry) which have the form of balls. (2) *Bacilli* (singular-bacillus; a Latin word meaning stick or staff), which are rod-shaped bacteria. (3) *Spirilla* (singular-spirillum; from a Greek word meaning a coil), shaped like corkscrews (see Figs. 35 and 43 and 44). The cocci and bacilli are the common forms, while spirilla are rare among disease-producing germs. Bacilli are far more numerous than cocci.

When bacteria divide into two they very often continue to cling together. This is quite characteristic with some bacteria, especially with the cocci. Their arrangement after dividing is sometimes so peculiar that they derive a portion of their name from it. Thus, some remain in masses resembling a bunch of grapes; these are called staphylococci. (See Plate II; Fig. 2.) Others form chains; these are called streptococci. (See

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EXPLANATION OF PLATE I

Gram-negative bacteria

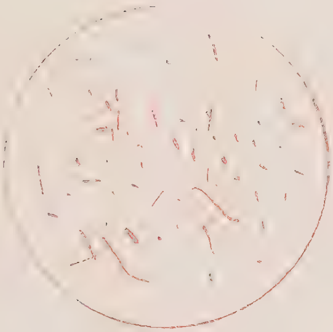
FIG. 1.—Smear of a broth culture of B. typhosus stained by Gram's method. Notice that size and shape vary considerably. All of these various forms are not always seen in a single culture. Magnified 600 times.

FIG. 2.—Smear of a broth culture of B. dysenteriæ. Note the similarity to B. typhosus. B. coli and B. paratyphosus have almost exactly the same appearance.

FIG. 3.—Smear from a broth culture of B. influenzæ. These are among the smallest of the ordinary bacteria. Note two or three rather larger forms. These are not infrequently seen in such smears. Gram's stain used. Magnified 600 times.

FIG. 4.—Smear from broth culture of gonococci. Stained with Gram's stain. Magnified 600 times. These are typical diplococci; that is they always occur in pairs. Note how they are flattened together. Meningococci present an almost identical appearance.

PLATE I



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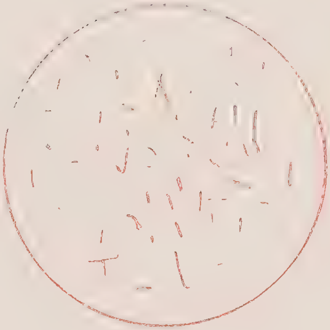

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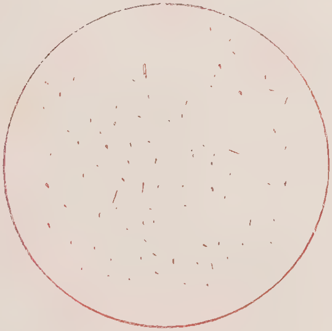

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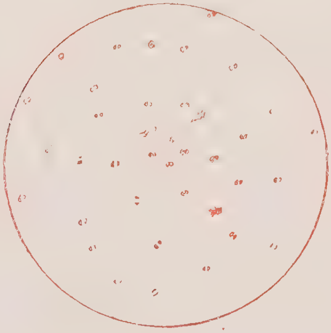

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For explanation see facing page

Plate II; Fig. 1.) Others are always in pairs; these are spoken of as diplococci. (See Plate II; Fig. 3.) We shall meet examples of each of these types in our study of disease germs. The bacilli vary in shape, (see Plate II; Figs. 4, 5 and 6) some being short and plump, others long and slender, and still others curved.

Staining of Bacteria.—In their natural state bacteria appear under the microscope as tiny colorless balls or rods which are difficult to see clearly. In order to be able to see them distinctly and to study them closely they are stained with aniline dyes. To accomplish this, a small droplet of the fluid which contains them (pus, broth, blood, etc.) is spread out in a thin film on a little piece of glass (called a "slide"). The film is allowed to dry.. It is then warmed rather vigorously, by passing through the Bunsen flame four or five times. *Do not scorch the film.* This fixes the film to the slide so that it will not wash off. The film is now ready to stain.

There are a number of methods of staining bacteria. Probably the most widely used of the simple methods is by means of a blue dye called *methylene blue.* A few drops of a solution of the dye are put on the film, prepared as above, allowed to remain there about fifteen seconds, and then washed off with a gentle stream of water. The slide is blotted dry (not rubbed) and is ready to examine.

Such a stain shows the shape and size of the germ very well. But there are other stains which give us more information about the organism. The most generally used stain for classifying bacteria was devised by a scientist named Gram and bears his name. It is called a *differential stain* because it differentiates the bacteria into two groups the *Gram-negative* and the *Gram-positive*.

The Gram stain is done as follows:—

1. After preparing the film as described above, cover it with a solution of gentian violet. (Formula may be found in any text-book of medical bacteriology.)

2. This is allowed to remain on for about 30 seconds and is then washed off.

3. A second solution called Gram's iodine is now applied for a like interval and washed off.

4. The smear is now bathed for about 10–20 seconds in pure (95 per cent) alcohol. At this point it is

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Explanation of Plate II

Gram-positive bacteria

Fig. 1.—Smear from broth culture of streptococci. Stained by Gram's method. Magnified 600 times. These are typical of the round, or ball like, bacteria which form themselves into chains.

Fig. 2.—Smear from a broth culture of staphylococci stained by Gram's method. Magnified 600 times. These are typical of the round, or ball like, bacteria which arrange themselves into irregular clusters. Note a number of pairs like diplococci, and one short chain of four cells. These are not infrequently seen in smears of these organisms.

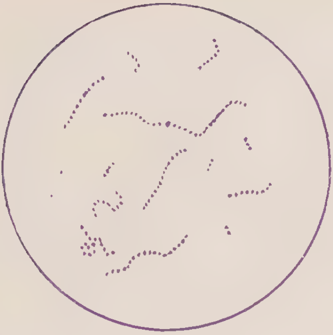
Fig. 3.—Smear from a broth culture of pneumococci stained by Gram's method. Magnified 600 times. Note that the cells occur in pairs. This organism is a diplococcus for this reason. Note also that the cells are not perfectly round but elongated or oval and that they are flattened together. Compare with the gonococci which are also diplococci.

Fig. 4.—Broth culture of B. anthracis. Gram's stain. Magnified 600 times. Note the rather square cut ends, the chain formation and the spores. At A are seen bacilli containing spores, at B is seen a spore free from its bacillus. The spores appear as light spaces because the ordinary stains do not penetrate them.

Fig. 5.—Broth culture of B. welchii. Gram's stain. Magnified 600 times. At A is seen a bacillus containing a spore.

Fig. 6.—Broth culture of B. tetani. Gram's stain. Magnified 600 times. Note the spores situated at the end of the bacilli. At B is seen a spore free from its bacillus.

PLATE II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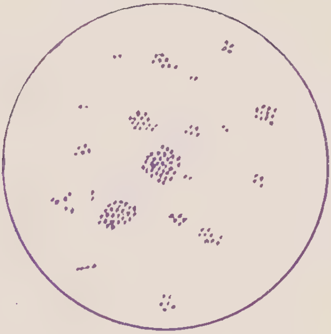
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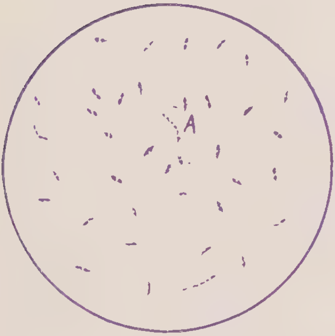

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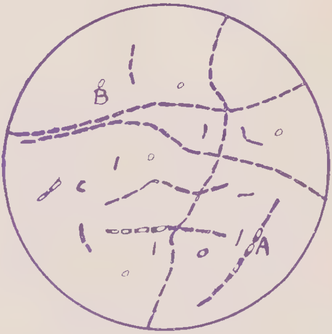

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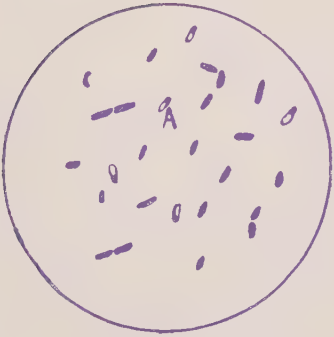

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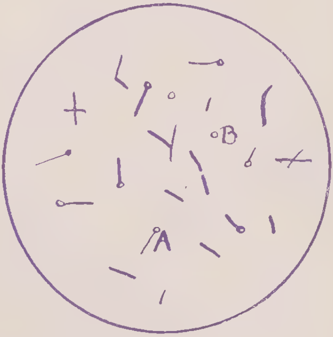

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For explanation see facing page

necessary to explain the difference between what are called *Gram-positive* and *Gram-negative bacteria.* Gram-positive bacteria will retain the gentian violet and iodine in spite of the alcohol and when viewed under the microscope will appear dark purple. The Gram-negative bacteria will not hold the stain when the alcohol is applied and when then viewed under the microscope will not have any color at all and will be as nearly invisible as when first put on the slide. Therefore, in order to make these bacteria visible:

5. The smear is flooded with a red dye called safranin. This is washed off after about 10 seconds.

6. The slide is now put between two blotters to dry it (never rub it) and is ready to examine.

The purple bacteria are the Gram-positive ones, (see Plate II) the red or pink bacteria are the Gram-negative ones. (See Plate I.) Sometimes, in material like feces, both kinds can be seen in the same smear and clearly differentiated.

There are bacilli which are Gram-positive, others which are Gram-negative. There are a great many different kinds of Gram-positive cocci and a considerable number of kinds of Gram-negative ones. Several of each type are discussed in this book. Other methods of staining will be discussed later.

Hanging Drop.—There are methods of examining *living* bacteria without staining them. The commonest method is by means of the *hanging drop.* This will probably be demonstrated in the laboratory. Briefly, it consists in focusing the highest, non-oil immersion lens of the microscope on a droplet of fluid containing bacteria and observing them there. The *diaphragm* must be partly closed. Much can be learned about bacteria by the use of the hanging drop. For example, some bacteria have the power of motion and in such a drop of fluid under the microscope may be seen darting, rolling, and squirming about, bumping into one another, clinging together for an instant and then separating again. The power of movement is due to extremely delicate, hair-like outgrowths on the sides and ends of the organism called *cilia*. (Fig. 7.) These cilia act somewhat like oars and propel the bacterium through the liquid. The most active bacteria move at the rate of about 1/1000 inch in a second. That is, they can travel a distance equal to their own length many hundreds of times in a second. They can move, however, *only in fluid, not through the air* or on solid

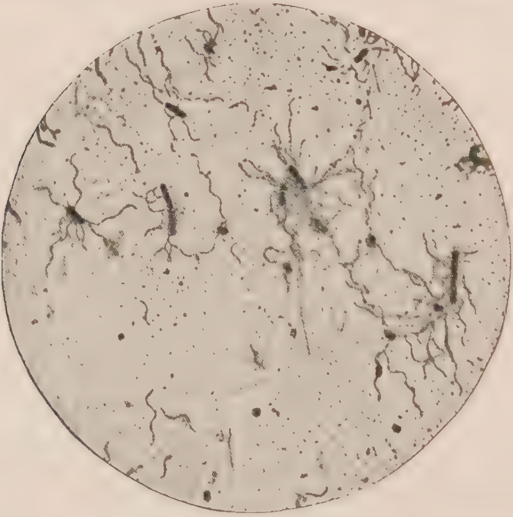

FIG. 7.—The typhoid bacillus, showing the thread-like outgrowths (cilia) by which the bacilli move through fluids. The bacilli must be specially stained to make these outgrowths visible (Williams).

substances. They may, however, be *carried* through the air as "passengers" on dust particles, hands, clothing, etc.

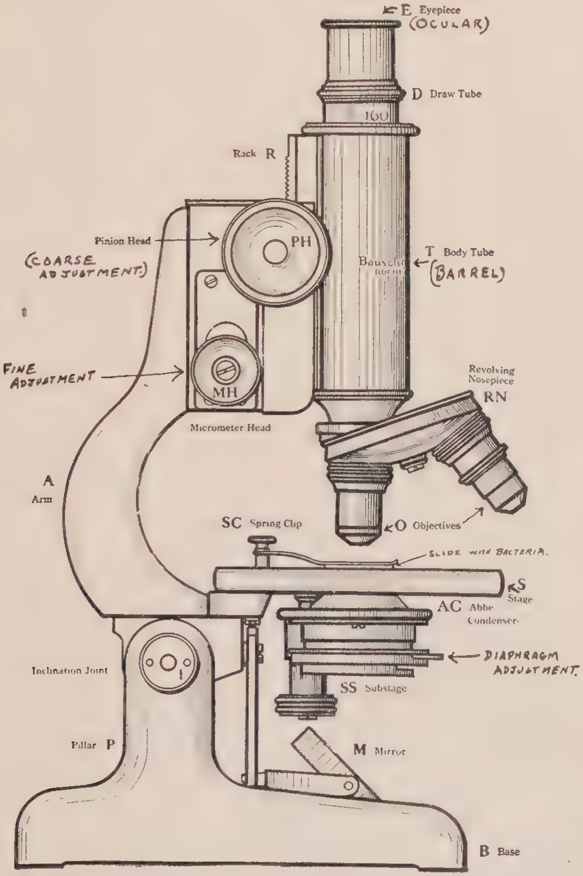

FIG. 8.—Diagram showing various parts of a common form of compound microscope used for studying bacteria.

The Microscope.—The modern laboratory microscope is quite expensive and complicated. Figure 8 shows the working parts. A few directions for the use and care of the microscope may not be out of place here.

For the study of bacteria a very powerful lens is necessary. The type most generally in use is called an "*oil immersion*" lens or *objective*. It is difficult for a beginner to focus or adjust an oil immersion lens. First, put a small drop of cedar or Russian oil on the smear to be examined. Place the slide upon the stage of the microscope, smear upwards. Adjust the mirror and diaphragm so that maximum light is reflected up through the smear. Now, with the *large wheel* (coarse adjustment) lower the barrel of the microscope, *watching the lowest point of the objective*, till the latter just touches the oil. Now, *very carefully*, lower the barrel still more until it almost touches the smear itself. Apply the eye to the ocular and raise the barrel with the large wheel *very slowly* until the smear comes into view. Make any subsequent adjustments of focus with the *small wheel*, (fine adjustment).

Never lower the barrel with the large wheel unless you are watching the objective: otherwise you are apt to break the slide and ruin the lens.

Always wipe the oil from the lens, after using, with a piece of soft cotton or lens paper.

Keep the instrument in its box or case to exclude dust.

Do not attempt to clean or repair the inside lenses or mechanism of your instrument yourself. Consult the instructor or someone familiar with such work.

If you have trouble in focusing it may be due to a poorly adjusted or dirty mirror, or poor source of light, dirty lenses, closed diaphragm, smear not under the lens, slide upside down, poor stain, lens mashed down on the slide, etc.

Growth and Cultivation of Bacteria.—Under the most favorable circumstances a single germ may divide in twenty or thirty minutes, in which case simple calculation will show that in twelve hours a single organism could give rise to over 68 billion. If conditions were always suitable the earth would be overrun with bacteria; but they, like all other living things, have to struggle for existence, and when conditions are unfavorable they multiply slowly or not at all.

Bacteria must have a suitable temperature for growth, each kind having a temperature at which it flourishes best. The germs which live in the outside world and cause putrefaction grow best at the temperature of mild summer weather (68–75° Fahrenheit); while those which live in the body and produce disease require more warmth and grow best at about body temperature (95–102° Fahrenheit). The lowest temperature at which bacteria can multiply is about 54° Fahrenheit, and the highest, 110° F. This does not mean that they are killed at these temperatures, for some bacteria are very resistant to both heat and cold; for example, the typhoid bacillus can survive for weeks in ice and there are bacteria which live in hot springs. Extreme heat is more quickly fatal to bacteria than extreme cold. The application of heat, in the form of either boiling water or steam, is one of the most widely used and efficient ways of killing bacteria. This will be further considered when we study methods of sterilization.

Bacteriological Media.—In the laboratory certain substances are used to induce the bacteria to multiply so that the student will be able to work with masses of them instead of with single cells. The substances used are of many sorts and are spoken of as *media* (singular-medium). One of the simplest of media is known as extract broth. This consists merely of a quite weak "beef tea," with a little salt and some dried and powdered, partly digested meat (called *peptone*) added to it. Such a broth is filtered and then carefully put into test tubes in 5 cc. amounts. (5 cc. is equal to about a tablespoonful.) It is then heated until sterilized. That is, all the undesirable bacteria which have accidentally gotten into it during preparation are killed. The reason for this will be discussed later on. Many bacteria will grow rapidly in such a medium. Usually, however, it is necessary to add a little soda or other alkali because of a slight acidity. This is usually done before putting it into the test tubes. It may be pointed out here that most of the bacteria which are discussed in this book are very sensitive to too much acidity or alkalinity. It is nearly always necessary to make the degree of acidity or alkalinity just right. This process is called *adjusting the reaction*. By the *reaction* is meant the degree of acidity or alkalinity. The most favorable reaction for most pathogenic bacteria is very slightly alkaline.

Various substances are added to broth to help the bacteria to grow and to see what changes may be produced in them by the bacteria. Blood is frequently added. The broth is then spoken of as "*blood broth.*" Various kinds of sugar, etc., are also added and the broth then takes its name from the substance added.

Pure Cultures.—One of the most important steps in studying any bacterium is preparing a pure culture of it. A *pure culture is one in which only one sort of bacterium exists*. A *mixed culture contains two or more sorts of* *bacteria.* A pure culture may be likened to a bed of pansies. In such a bed there are nothing but pansies and we might say that the gardener had made a pure culture of pansies. If some geraniums or other sorts of plants were put in the bed also, we might say that the gardener had prepared a mixed culture. If weeds got in accidentally we could say that the culture of pansies was *contaminated.* Likewise, when some undesirable bacteria get into our pure culture of bacteria we say that the culture is *contaminated.*

In preparing a pure culture it is very convenient to have a solid surface on which to spread out the mixture and then pick out the kinds we want and put them in test tubes of media by themselves, there to multiply. A very useful substance for this purpose is agar-agar, which is a form of dried seaweed from Japan. It is often used also as a cathartic. When properly purified and put in boiling water or boiling beef broth it melts like gelatine and on cooling "sets" to a firm jelly. If some of this beef-broth-agar be made sterile and then poured into a sterile, covered dish and allowed to cool, we can spread out on its surface a droplet of the bacteria-containing fluid (saliva, for instance) and then select the bacteria we wish.

The question at once arises—how, if bacteria are so small as to be invisible, can one pick them from a jelly surface? It is simplicity itself. The agar contains beef broth which will nourish the bacteria. Put the dish in a warm place. The bacteria multiply. In 24 hours masses of bacteria are usually visible to the naked eye on the surface of the food substance. These masses, each of which is composed of millions of germs, are called colonies. Each colony consists of all the

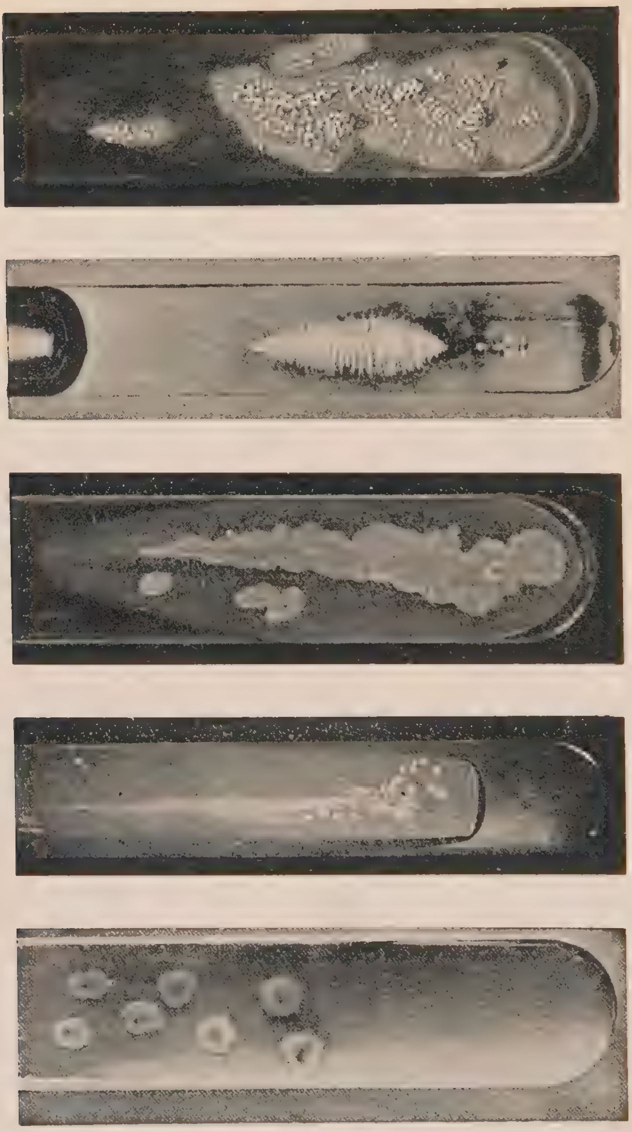

FIG. 9.—Various forms of colony.

descendents of the single bacterium which landed on that particular spot 24 hours before. All of the members of a single colony, therefore, being descendents of a single cell, are of one kind. All that is now necessary, to obtain a *pure culture* from any one colony is to touch it with the end of a sterile wire and transfer the sterile wire to whatever kind of medium we desire. This in turn is *incubated* for 24 hours.

Colonies of different bacteria vary in appearance. (Fig. 9.) Some look like dewdrops; others are white and glistening like the head of a white pin; still others have various colors. When bacteria grow in broth they cause a cloudiness.

The bacteriologist identifies the organism in a culture by several methods. *First*, he smears it and stains by Gram's method and then examines it under the microscope. This shows whether it is a coccus, a bacillus, or a spirillum, and how the individual bacteria are arranged, whether in bunches, chains, etc., and whether it is a member of the Gram-positive or the Gram-negative group. Bacteria, however, are so limited in their shapes and arrangements that microscopic examination alone is insufficient to identify them. Organisms which stain alike and look the same under the microscope may be entirely different in their characteristics.

Second, he studies the way an organism grows on different food substances, the appearance of its colonies, their size, shape, color, etc. This, combined with its appearance under the microscope and staining reaction, often gives definite clues as to what germ we are dealing with.

The third method of study is to find out what *chemical changes* the particular organism which we are studying can bring about in various test substances. As has been mentioned, bacteria can cause, by means of their enzymes, a great variety of chemical changes very quickly under favorable conditions. They can decompose complicated substances into simple ones and build up complex compounds from simple materials. They can form acids and gases, clot milk, liquefy gelatin, and bring about the changes which we call putrefaction and fermentation. Not all bacteria can do all these things, but the ability of each kind of organism to bring about certain chemical changes is known. We therefore study what our organism can do, as well as what it and its colonies look like. Practically, this is done, as has just been indicated, by transferring small droplets of a pure culture into tubes of sterile milk, gelatin, broth, solutions of cane sugar, milk sugar, etc., and examining the cultures at the end of 24 hours and later. It is important to realize that it is not only in the laboratory that bacteria can produce these chemical changes, but that they are continually bringing about similar reactions in the world around us. We shall study some of these activities further when we take up the study of the different kinds of bacteria.

Fourth, in studying disease-producing bacteria, it is frequently necessary to inject or inoculate them into *animals* (Fig. 10). This is the only way in which the action of bacteria on the living body can be studied directly, exactly, and under varying conditions, for we cannot experiment on human beings. Animals react to many kinds of bacteria in much the same way as man reacts, and the organisms cause the same kinds of changes in their bodies. The sciences of bacteriology and medicine could never have developed without the study of the action of bacteria on animals and the experiments which can be performed on them. The animals most often used for this purpose are guinea pigs, white mice, and rabbits.

Furthermore, the inoculation of animals may be useful in making a diagnosis on patients, for some bacteria grow better and more quickly in the bodies of animals than in test tubes. For instance, tubercle bacilli are difficult to grow in the laboratory, but by inoculating a guinea pig with the suspected material (sputum, urine, or pus) a positive diagnosis may be obtained more quickly and surely. The animal will rapidly develop tuberculosis, and an autopsy will demonstrate the condition. It is of the greatest advantage to a patient to determine as soon as possible what bacteria are causing his trouble, and the inoculation of animals often helps toward this end.

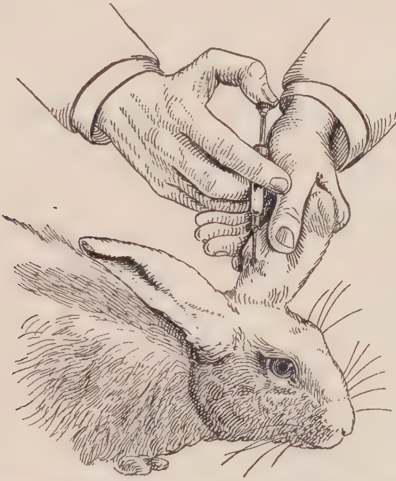

FIG. 10.—Injection of bacteria into a rabbit through a vein in the ear (McFarland).

CHAPTER IV

THE DESTRUCTION OF BACTERIA. METHODS OF STERILIZATION AND DISINFECTION

Nature's way of destroying bacteria is by drying, sunlight, insufficient food, and an unfavorable temperature. We also make use of these; but in practical life, and especially in medicine and surgery, Nature's methods are insufficient. Special methods have therefore been worked out for the destruction of bacteria by what we call sterilization. These methods have made possible modern surgery and obstetrics. In the days before methods of sterilization had been developed, surgical wounds quite regularly became filled with pus, and a large proportion of the patients died of infection. Because of this danger of infection only the most urgent operations were attempted. Surgeons never dared to open the abdomen, the chest, or the head unless they had already been opened by a wound or accident. Countless women also died of puerperal fever. Surgical and maternity wards were depressing places in those days. The famous English surgeon, Lister (see Frontispiece) (1827–1912), one of the greatest benefactors of mankind, was the first to apply methods of sterilization in surgery. In medicine, as well as in surgery and obstetrics, methods of sterilization are of the greatest importance in limiting the spread of the germs causing the infectious diseases. In the preservation of food, also, sterilization is essential to kill the bacteria which cause putrefaction.

Sterilization is the destruction of all bacterial life. There are two general methods in practical use: first, the application of heat; and second, the use of chemical substances, called disinfectants or germicides. When a substance does not actually kill the bacteria but merely stops their growth and multiplication, it is called an antiseptic. Mouth washes, gargles, and irrigations have usually an antiseptic rather than a sterilizing action.

Asepsis means the absence of living bacteria. In surgery, everything which comes in contact with the wound is first made sterile by appropriate methods of treatment before the operation, and then, during the operation, asepsis is maintained by keeping the sterile objects from contact with anything which is not sterile. *Aseptic technic* is very simple in principle, but it requires much practice and constant attention to carry it out accurately. A single moment of carelessness may allow the contamination of an article and destroy all the value of the most painstaking preliminary sterilization. The aseptic method is also the method of bacteriological technic.

Methods of sterilization may be tabulated as follows:

I. HEAT.
  (A) Moist
    1. No pressure.
      (a) Boiling.
      (b) Fractional or intermittent.
    2. Pressure.
      (a) Autoclave.
  (B) Dry.
    1. Incineration.
    2. Oven baking.

II. Chemical (Use of disinfectants).
  (A) Four main principles.
    (a) Time allowed for action of disinfectant.
    (b) Temperature of disinfectant.
    (c) Concentration of disinfectant.
    (d) Penetration of disinfectant into masses of material.

III. Mechanical.
  (A) Filtration with porcelain filters.

Application of Moist Heat.—*Boiling* needs little discussion. It is used chiefly for surgical instruments, dishes, infected linen, etc. For surgical instruments three minutes boiling is usually used. There are few spores which can resist five minutes boiling.

There are *two methods of sterilizing by steam:* First, by "live" or streaming steam, that is, just as it rises from the surface of the water; and second, by steam under pressure, as in the autoclave of the operating room.

Sterilization by live steam is called *discontinuous*, *intermittent*, or *fractional*, because the process must be repeated for three days in succession in order to kill spore-forming bacteria. Briefly this is explained as follows: some kinds of bacteria have developed means of resistance to heat and other conditions unsuitable for life by the formation of what are called *spores*. This process is not common among disease-producing germs, but frequent among those living in the outside world. When an organism is about to form a spore, a glistening speck appears at one end. This increases in size, becomes surrounded by a dense covering, and is now called a spore. This may leave the bacillus, which is now nothing more than an empty shell, and may be blown about with dust. The spore is dormant like the seed of a plant. In this form the germ has a remarkable power of resistance to heat, cold, drying, antiseptics and other unfavorable conditions. When conditions again become favorable for the life of the germ, the spore "sprouts," or germinates, changes back to the ordinary form of the organism and goes on growing. Spores can remain alive for a long time but show no signs of life until they are placed under favorable conditions for growth.

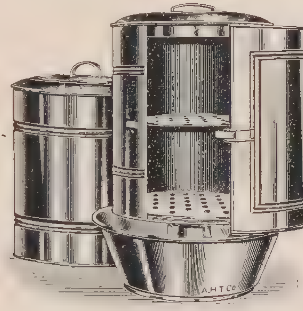

FIG. 11.—Arnold sterilizer for fractional sterilization.

The bacterium, before the spore has formed, is said to be in the *vegetative state:* Now if we apply streaming steam for an hour on Monday, we kill all the vegetative forms, but the spores are not killed. If the material containing the spores be kept at body temperature overnight, however, the spores germinate and become vegetative. On Tuesday streaming steam is again applied for an hour and the newly vegetated bacteria are killed. In order to be doubly safe the heat is generally applied a third time to kill any spores that may have been slow to germinate the second day. This method is not used to any extent in hospital work, but it is employed in the laboratory and

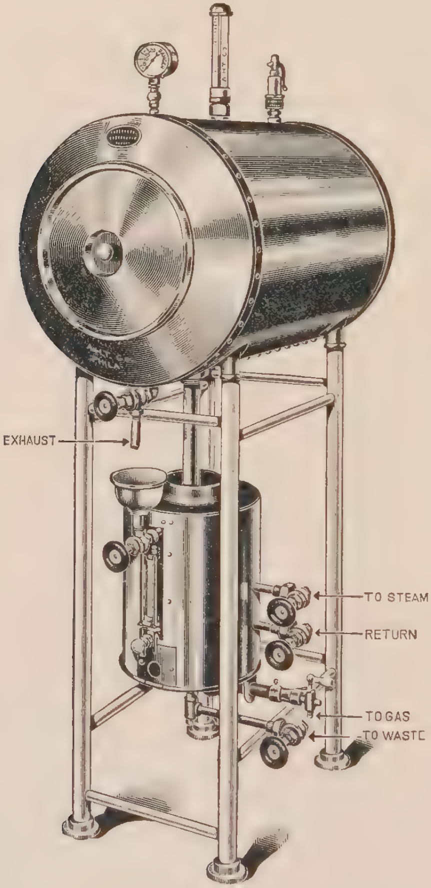

Fig. 12.—Horizontal type of autoclave.

is widely used by housewives in the so-called "cold-pack" method of canning goods. The apparatus is shown in Fig. 11.

The use of **steam under pressure** is the most useful method of sterilization by heat, and is the one generally used in hospitals for articles which cannot be boiled. Steam *under pressure* has tremendous *penetrating power,* and its *temperature rises far above that of boiling water.* These characteristics give steam its special value for sterilization.

The apparatus for sterilizing by steam under pressure is called an *autoclave,* (Fig. 12) and every nurse becomes familiar with its management during her training in the operating room. An autoclave is essentially a metal cylinder with a door which can be screwed down tightly. The closed cylinder is filled with steam from the hospital boiler until the pressure reaches the desired point.

Autoclaving can be used for any objects that are not injured by moisture or by very high temperatures, such as dressings, solutions of various kinds, etc. Exposure to steam under 15 pounds pressure (which is what is ordinarily used in an autoclave) for fifteen to twenty minutes is sufficient to kill all bacterial life, including spores.

Incineration is much used by cities in disposing of garbage and other refuse. Sputum cups and other infectious materials are often burned up. It is the cheapest and easiest and best method in such cases. In the laboratory, the wires used for transferring bacterial cultures are heated to redness in the flame before and after using.

Oven Baking.—Many materials are spoiled by the application of moisture. Laboratory glassware, certain sorts of dressings, etc., have too much condensed steam adhering to them after autoclaving. For this reason such articles are sterilized by the application of dry heat in an oven. The temperature is necessarily much higher than the autoclave, and longer exposure to dry heat is needed to kill spores. Ordinarily, two and a half hours exposure to a temperature of 175° C. is sufficient. This application of heat usually just begins to turn cotton and paper a light brown or tan color.

The use of an oven is often very desirable in home nursing where no autoclave is available. The exposure may be controlled by leaving the materials in the oven just long enough to turn the wrappings of the bandages, or a piece of newspaper, a light brown. A slow oven is preferable, as it allows the heat time to penetrate.

Disinfectants.—Many chemical substances have the power of killing bacteria, but comparatively few are suitable for general use. The nurse will become familiar with those most in use in hospitals. Disinfectants differ in their power to destroy organisms; some are much more effective and reliable than others. Many of the widely advertised patent germicides have comparatively little disinfectant action. Bacteria also differ in their power to withstand disinfectants; some are killed easily, others are quite resistant. Spores are extremely hard to kill.

No one disinfectant is suitable for all substances or under all conditions. Some are too irritating or too poisonous to use on the skin or in wounds; others rot cloth or rust metal; others are too expensive for general use.

Among the most *common* and *reliable* disinfectants are bichloride of mercury, carbolic acid, lysol and creolin, tincture of iodine, 70 per cent alcohol, chlorid of lime, and mercurochrome.

Bichloride of mercury is one of the most valuable disinfectants. In a dilution of 1 to 1000 it kills most bacteria within half an hour. Its disadvantages are that it corrodes metals, is rather irritating to the skin, and is very poisonous. It also coagulates substances containing albumen, like sputum, blood, and pus. Bacteria, when encased in coagulated material escape its action. Further, when it causes coagulation it becomes more or less inactive. It is therefore not good for disinfecting material which will coagulate when it is added.

Mercurochrome has been developed only within the last two or three years. It is a compound containing mercury. It is used often on cuts, wounds, etc., in place of iodine. It is not safe to use when there is much danger of its being absorbed by the body extensively since mercury is poisonous. It is, however, often injected into the blood of patients. Its disinfecting power is said to be superior to that of bichloride of mercury.

Carbolic acid (phenol) is a very useful disinfectant. It is generally used in 3 per cent solution. It does not cause coagulation, is less irritating to the skin and does not corrode metal or rot cloth.

Lysol and *creolin* contain carbolic acid and certain tar derivatives. They are used in 1 to 2 per cent solution, and are good germicides.

Formalin in 10 per cent solution has a wide range of usefulness as a disinfectant. It may be used to sterilize feces, urine, sputum, and similar substances, and also clothing. It deodorizes as well as disinfects. The material to be disinfected should be allowed to stand in the solution at least two hours. It is quite irritating, but otherwise has the same advantages as carbolic acid.

Tincture of iodin and 50 *per cent alcohol* are used in disinfecting the skin.

Lime is one of the best and cheapest germicides we have. It is used either as lime or chlorinated lime, the so-called "chloride of lime." Lime is used as "milk of lime," which is made by adding one part of lime to eight parts of water. It should be freshly prepared each time that it is to be used, and added in quantity equal to the amount of material to be disinfected. The mixture should stand at least two hours. *Chlorinated lime* is used in 4 to 5 per cent solution. Lime and chlorinated lime are extremely valuable for disinfecting water supplies. The addition of 5 parts of chlorinated lime to 1,000,000 parts of water will kill many disease germs.

There are several *general principles* in connection with disinfectants, which are important to remember. First, a *hot* germicidal solution is much more powerful than one of the same strength cold. Second, sufficient *time* must be allowed for the disinfectant to act. Very few disinfectants act immediately, even in strong solutions. Third, disinfectant solutions have very little power of *penetrating* into the interior of solid masses. Therefore the material, such as feces or sputum, must be broken up and thoroughly mixed with the disinfectant. It is extremely important to do this otherwise the bacteria in the center of the mass will not be exposed to the disinfectant and killed. Fourth, the disinfectant must be sufficiently *concentrated* to act within the time allowed.

Food is preserved from the destructive action of microörganisms by one of four methods; by heat (canning); by cold (cold storage); by the use of preservative substances of various kinds, such as sugar, salt, and vinegar; and by drying. It is now possible to preserve every kind of food material by the use of appropriate methods. Food preservation is of the greatest importance in our complicated modern life. It provides people in cities with an abundance and variety of food in wholesome condition. It prevents waste by making possible the saving of food when and where it is plentiful so that it may be available in time of scarcity. Methods of food preservation all depend on bacteriological principles. Some methods, like drying and pickling, have been practised for centuries, while canning and cold storage are modern developments.

The *principles of canning* are just the same as those of surgical sterilization; that is, the destruction by heat of all bacteria present, and the protection of the material from the entrance of other germs. In the household this is done either by boiling or by steam sterilizing. By the older method the fruit and vegetables are boiled, the jars, covers, and rings are sterilized by steaming in water, the jars are filled to overflowing, and sealed air-tight while boiling hot. By the newer "cold pack" method, the fruit and vegetables are put into the jars cold and are sterilized by steaming in a boiler on three successive days. This method preserves the color and flavor better than does the method of boiling. In canneries steam under pressure in an autoclave is used.

The principle underlying *cold storage* is that food can be preserved for a long time if it is kept at so low a temperature that bacteria cannot develop. The bacteria present in the food when it is put in cold storage are not killed, but they cannot multiply. Meats, fish, and poultry are frozen; eggs, fruits, and vegetables are kept just above the freezing-point. Some foods deteriorate slowly in cold storage. There is, however, an unreasonable prejudice against cold-storage goods. They may, as a matter of fact, be really "fresher" than goods which have been kept a shorter period of time at higher temperatures.

Pickling in either brine or vinegar preserves food because a strong salt or acid solution kills many microorganisms. Large amounts of sugar also prevent the growth of bacteria; this is the principle of putting up fruit cold in a thick syrup, also of condensed milk. Dried meats, vegetables, and fruit do not spoil because they contain too little moisture for the growth of bacteria. In the process of smoking meat or fish the material is not only dried, but certain antiseptic substances pass into it from the smoke.

Pasteurization (named in honor of the great French bacteriologist, Pasteur) is the process of *partial* sterilization which is used to preserve milk and to kill any *disease germs* which may be present. It consists in heating milk to 140° F. for thirty minutes, followed by rapid chilling. This kills practically all *disease germs*. It also kills most of the acid-producing bacteria which normally occur in milk so that milk which has been pasteurized sours very slowly. Practically all the milk sold by large city firms, under present regulations, has been pasteurized.

Filtration.—It is possible to sterilize various fluids without heat or disinfectant. This is accomplished by passing the fluids (if they are not too viscous) through a filter made of fine, unglazed clay. The apparatus used for this purpose is shown in diagram in Fig. 13. The whole is carefully sterilized in the autoclave to start with. A rubber tube connected with a suction pump is then attached to the stem of the flask and the fluid to be filtered is poured upon the clay "candle." The suction draws the fluid through into the flask but the bacteria and all other particles are held back by the clay. The fluid is then removed from the flask with sterile pipettes. *There are some organisms much smaller than bacteria which may pass through such filters. These are called filterable or ultra-microscopic viruses* and will be discussed in a subsequent chapter.

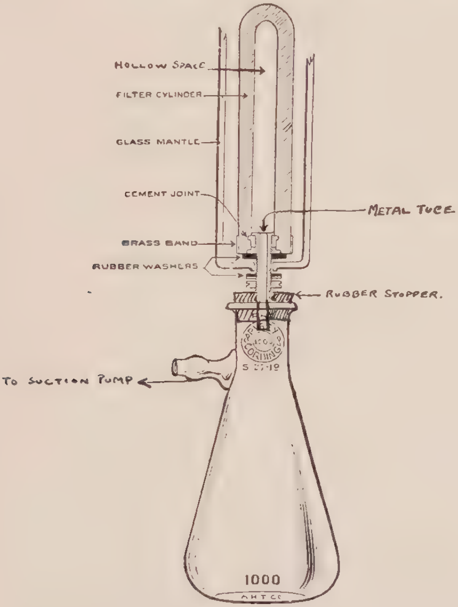

FIG. 13.—Arrangement of bacteriological filter.

CHAPTER V

INFECTION AND IMMUNITY

Infection.—Disease and infection may be regarded as a struggle between an attacking force and a defending body. The bacteria represent the invaders. Both sides have their means of offense and defense. We shall first consider the struggle from the viewpoint of the bacteria.

Bacteria may gain entrance to the tissues of the body and grow in them, injuring them and producing symptoms. When this happens the result is called an *infection.* The word infection has a very broad meaning and is used for conditions that vary greatly in severity. Some infections are so mild that they cause almost no discomfort; others are fatal. A pimple, for example, is a trivial infection of the skin; typhoid fever is a serious and often fatal infection of the blood and intestine and other organs.

Portal of Entry.—There are *certain routes or pathways by which bacteria enter* the body and cause infections. The most important of these pathways are through the skin, the respiratory tract (nose, throat, and lungs), the mouth and gastro-intestinal tract, and the genital tract (vagina and uterus in the female, urethra in the male).

The pathway by which an organism enters the body is of great importance in determining whether or not disease shall occur. Each kind of disease germ has its favorite pathway, and the majority of them can cause an infection only if they enter over their own particular route. Thus, typhoid bacilli rubbed into a wound of the skin would probably give rise to no trouble, while the same organisms, if swallowed, might cause fatal typhoid fever. On the other hand, the cocci which cause inflammations of the skin (Chapter XI, Sec. II) may give rise to no harmful effects when swallowed, while if rubbed into the skin or a wound they would produce a severe infection.

Bacteria floating in the air enter the body through the *respiratory tract.* The germs of tuberculosis and pneumonia may be scattered through the air attached to particles of dried sputum. They are also thrown out in the spray formed by the patient during coughing or sneezing, and may be breathed in by any one nearby. Organisms entering through the nose or mouth may take one of several paths. They may be swallowed and so reach the stomach and intestines; they may stay in the nose and throat and produce an inflammation there, as, for instance, a cold; they may locate on the tonsils, as in the case of diphtheria and tonsillitis; they may pass on to the lungs, as they do in pneumonia and tuberculosis. From the throat, tonsils, and lungs organisms may pass into the circulating blood and start an infection in some of the internal organs or in the brain and spinal cord.

Virulence.—After gaining entrance to the body, the pathogenic bacterium must have some means of maintaining itself there, otherwise it would perish. It accomplishes this because of the property spoken of as *virulence.* Virulence may be regarded as a combination of two other properties. The first of these is *aggressiveness.* That is, the bacterium can live and multiply on the tissues or in the blood of the body without difficulty. Its aggressiveness consists in its proceeding to do so and to invade the whole system without delay. The second property is called *toxicity.* Toxicity simply means poisonousness. If the bacterium is poisonous, or if it secretes a poisonous enzyme, as was mentioned in Chapter I, then it need not be so very aggressive in order to be virulent and to do a great deal of damage to the body. It may lack aggressiveness almost entirely and not be able to get inside the tissues at all. Yet, if a few very toxic germs lodge in the throat on the tonsils or elsewhere on the outer surfaces, they may, by producing their poison, which is absorbed and carried all through the system, kill their victim.

This is exactly what happens in diphtheria. The bacteria which cause this disease lack aggressiveness almost entirely. They practically never get further into the tissues than just the surface of the tonsils and adjacent portions of the nose and throat. Yet by maintaining this slight foothold, they can fatally poison the patient. They are extremely virulent bacteria because of their toxicity but not because of their aggressiveness. Other bacteria, like the anthrax bacillus (Plate II, Fig. 4), are just the reverse. Although possessing absolutely no toxicity they are very virulent because of tremendous aggressiveness. Indeed, they may grow so extensively in the blood as to clog up some of the smaller vessels, especially those that supply the brain and heart and produce death in this way.

Toxicity ——↘
Virulence
Aggressiveness ↗

It must be remembered that it is not the *aim* of bacteria to kill their host for this in turn kills themselves. The death of the victim is merely an unfortunate result of their greed for his body substances to live upon. When he dies his temperature becomes too low, and changes occur in his body which make it impossible for them to survive there.

Toxins.—Now bacteria which are poisonous may produce their *toxin* in one of three ways. First, they may merely consist of poisonous protoplasm. Second, they may form a poisonous, enzyme-like substance (*toxin*) which remains enclosed within the cell membrane. Such a toxin is called an *endo-toxin* (endo = inside). Third, they may form a toxin which diffuses outward through the cell membrane. Such a toxin is called an *exo-toxin* (exo = outside).

The toxins of bacteria are quite complicated chemically. Indeed, little is known about them from a chemical standpoint, except that they are derived from, and somewhat resemble protoplasm or protein. Just how they injure the tissues of the body is not very clearly understood either. But that they do so is quite evident. The toxin of each bacterium differs from all others. Thus, diphtheria toxin, an exo-toxin, injures the kidneys and heart particularly. The toxin of the germ causing lockjaw (also an exo-toxin) injures nerves and thus produces the spasms of lockjaw. As has been mentioned, it is unfortunate for the germs themselves that they produce fatal poisons, because these destroy their source of food by killing it. The toxins do, however, help to weaken the defense of the body and thus enable the bacteria to make the most of their victim while he survives.

Resistance.—Now let us view the struggle between bacterium and body from the standpoint of the defending body—the host.

Inflammation.—When bacteria invade the body they cause certain symptoms by the action of their poisons on the various organs. They also damage the tissues at the place where they enter the body or where they locate. The tissues respond to this injury; they try to stop it, to get rid of the bacteria, and to repair the damage. The visible part of this *effort of the tissues* we recognize as *inflammation*. Inflammations of various parts of the body are familiar in everyday experience, as boils, infected scratches or cuts, etc. Every kind of germ causes inflammation when it invades the body, but some give rise only to very slight inflammation. There are two grades or degrees of inflammation, *acute* and *chronic*. An acute inflammation is one which lasts a number of days; a chronic one, weeks or months.

The changes present in every acute inflammation are redness, swelling, heat and pain. These may be observed in an abscess or an inflamed joint. The redness is due to the increased amount of blood and dilatation of blood vessels; the pain, to pressure on the small nerve branches in the tissue. The swelling and heat are caused partly by the large amount of blood and partly by the complicated changes which are going on in the tissue. The poisonous substances formed by the bacteria injure the cells of the tissue. These substances attract the white cells of the blood, or the *leucocytes*, to the injured spot.

Inflammation is usually accompanied by the formation of pus, but not always so. A mild inflammation may heal without the formation of pus, and in some severe inflammations, such as erysipelas, no pus is formed. When the inflammation and pus formation are localized in one spot, we have an abscess. In the healing of severe and extensive acute inflammations, and in chronic inflammation, *connective tissue* is formed which we recognize as a *scar*.

Bacteria are the cause of inflammation in the great majority of cases, but it is possible to have inflammation caused by irritating substances when no bacteria are present. Poison ivy or mustard, for instance, can produce an acute inflammation of the skin. Heat and cold can also cause inflammation, as we see in a burn or frost bite. *Inflammation in its broadest sense is the response of the body to injury of any kind.*

We see that inflammation has both an injurious and a beneficial side. The damage caused by the bacteria is harmful. The response of the tissue and the activities of the leucocytes are protective, because they tend to destroy the bacteria and repair the damage which they have caused. The study of what happens in inflammation gives us further insight into the struggle between the body and the invading bacteria which takes place in the infectious diseases. If the entrance of bacteria into the body were not followed by some protective reaction, like inflammation, everyone would sooner or later succumb to an infectious disease.

Other Means of Defense.—The body has very efficient ways of protecting itself against bacteria in addition to the inflammatory reaction. In the first place, as we have mentioned above, the body is protected against bacteria, first, by *simple mechanical means.* One of the important functions of the skin is the mechanical protection of the tissues underneath from bacteria and other forms of injury.

The unbroken skin is a perfect protection against bacteria; they cannot get through it. If, however, the *skin* is injured or torn, bacteria may enter the underlying tissues. Here they may find favorable conditions for growth and multiply, causing an inflammation, usually with the formation of pus. Breaks and injuries of the skin which are so small that they are overlooked may offer a place of lodgment for germs. The danger of neglected accidental wounds and cuts is that they may be the starting point of a serious infection.

The conjunctiva is protected by the motion of the eyelids and the constant washing of the tears, which carries the bacteria down into the nose.

The lungs are safeguarded by the complicated arrangement of the nasal passages with their moist mucous membrane. These act as a trap which catches most of the incoming bacteria. The bacteria which get by and pass into the lungs are carried out again by the action of the cilia on the cells lining the trachea and bronchi (air passages to and in the lungs).

The intestines are protected by the acid gastric juice, which kills many harmful bacteria.

The Leucocytes.—The body is protected by the action of the *leucocytes* which devour the bacteria. The action of leucocytes has already been described in Chapter I. They take up other things as well as bacteria; bits of useless or harmful material of various kinds, such as coal dust, or the remains of red corpuscles. They can dispose of a comparatively large mass by removing it piecemeal. The "core" of a boil is gradually carried off by the leucocytes, as are also silk and catgut ligatures. The leucocytes are attracted by anything abnormal or unusual in a tissue or in the blood, like bacteria, a slight injury, a haemorrhage, the presence of a poison, or any dead or useless tissue.

Certain infections always cause an increase of the leucocytes in the circulating blood; others do not. Among those in the first group are infections caused by staphylococci, streptococci, and pneumonia germs; in the second, typhoid fever, measles, influenza, tuberculosis, and syphilis. There is a simple method of determining the actual number of leucocytes in a cubic centimetre of blood by diluting it and counting the leucocytes under the microscope. The nurse will often see the doctor taking blood for a leucocyte count for the purpose of making a diagnosis.

There are other cells in the body which act like leucocytes in engulfing foreign particles. They differ from leucocytes, however, in being at the same time parts of certain organs and do not move freely. For example, there are *phagocytic cells* in the liver and spleen and bone-marrow.

Antibodies.—Another method by which the body protects itself is by producing *substances which in one way or another are injurious to the invading bacteria*, or which neutralize their toxins and thus make the toxins harmless. All such substances are called *antibodies*. It is these which we shall discuss more particularly in the following pages.

The presence of the bacteria, or their toxins, in the body stimulates it to produce these substances. The antibodies are of different kinds. Some antibodies counteract the poisons, or toxins, formed by the bacteria.

These are called *antitoxins*, and the most familiar example of them is that which acts against the poison of the diphtheria bacillus, or *diphtheria antitoxin.* Another kind of antibody dissolves the invading bacteria; these are called *bacteriolysins:* (lys = to dissolve): another affects them in some way so that they are more easily taken up by the leucocytes; these are called *opsonins* (from the Greek—to prepare food for). Still another kind gathers bacteria into clumps; these are called *agglutinins* (to glue or stick together). There are still other kinds of antibodies.

The antibodies are present in greater or less amount in the circulating blood of patients having an infectious disease, and they can be tested for by laboratory methods. *The antibodies produced in any infectious disease are directed only against the organism causing that disease.* For instance, those produced during typhoid fever protect *only against typhoid bacilli.* They would be of no value against diphtheria bacilli or pneumococci. Antibodies are therefore said to be *specific.*

Both the poisons formed by the bacteria and the substances produced by the body to counteract them are extremely complicated and delicate. They have not yet been obtained in pure form outside the body, and they are known and studied only by the effects which they produce in the bodies of men and animals. They are tested for by examining the serum (Chap. I) by various complicated methods. It is only within the last thirty years that anything has been known about these substances, and even now scientists are only beginning to understand the methods by which the body protects itself. In the case of many infections these are still unknown.

CHAPTER VI

ACQUIRED IMMUNITY

Immunity is that property, due to the presence of antibodies in the blood, which enables us to resist infection. There are several ways of becoming immune to disease.

I. Natural Immunity.—Nature's way of producing immunity is allowing one to have a disease and recover from it. The patient who has recovered from an infectious disease may seem to be just the same as before, but in reality he is very different, because he has gained, for a longer or shorter period, a *resistance* to that disease. The resistance is due to antibodies in his body which are capable of destroying the bacteria in question. A person who has had scarlet fever, measles, or typhoid is immune to these diseases for the rest of his life; that is, second attacks are extremely rare, even though the person is in contact with the disease. *Antibodies remain in the body for varying lengths of time after the patient has recovered from an infectious disease, the time depending on the disease.* After pneumonia especially they disappear quickly, within a few weeks; whereas after typhoid they remain in the body for many years. *As long as they continue in the body the person is unlikely to have the disease a second time, even if exposed to it.* This natural method is a hard way of acquiring immunity, and often a dangerous and uncertain one, for many people die from infectious diseases.

Natural Resistance.—Good resistance to disease usually means, in a general way, vigorous health and good personal hygiene. This is not always true, however, for some infections, such as typhoid and scarlet fever, have no relation to the general health, but often strike down the young and robust.

The *conditions which lower resistance* to disease and allow bacteria to gain a foothold are many and various. Our vague expressions, "depressed vitality," "lowered tone," "general debility," and "weakened constitution," mean a condition in which resistance to infection is diminished. The chief causes which lower resistance and favor infection are exposure to wet and cold, fatigue, bad air, insufficient or unsuitable food, insufficient sleep and rest, worry, and excessive alcohol. It is a matter of common observation that these conditions make us more liable to contract certain diseases, but exactly how they act is not clear. Chronic diseases not caused by bacteria, such as cancer, diabetes, and some nervous diseases, also make a person more liable to infections which often end the patient's life.

Parts of the body in which there is poor circulation or interference with the nerve supply are easily attacked by bacteria. Every nurse knows the care which must be taken of swollen or paralyzed limbs, and the watchfulness necessary to prevent bedsores in parts, the circulation of which is interfered with by pressure. Under such circumstances a scratch or small break in the skin may be the starting point of an extensive ulcer.

II. Artificial Immunity.—In recent times scientists have discovered methods of *producing immunity* without forcing the patient to go through the regular course of a disease. There are three general methods of accomplishing this.

First, in the case of some infections it is possible to immunize the person *before he has the disease*, that is, to make him resistant to the disease and thus prevent him from having it at all. When disease-producing bacteria enter the body of such an immunized person they are met by the defensive substances and are overpowered. This method of protecting against a disease is spoken of as *prophylactic* or *preventive* immunization. The *usual* method consists in injecting the dead bacteria into the system. The system reacts just the same as though the bacteria were alive, but of course the reaction is only temporary and no actual infection occurs. This is practised on a large scale in the prevention of typhoid fever. The process is called "vaccination" but differs from smallpox vaccination, as will be described later on.

Second, when a person is *already suffering from an infection* the amount of protective substances in the blood may, in some cases, be increased by giving the patient injections of the serum of some animal which has been purposely made immune to this particular disease. This brings the antibodies of the animal to the patient quickly, thus immunizing him and cutting short the natural course of the disease. An example of this is the use of antitoxin in diphtheria.

Third, it is possible, in a very few cases, to give the person the disease in an exceedingly mild form, which, however, will protect him from the usual severe form of the disease. This is done in vaccination against smallpox.

The practical applications of each of these methods for the prevention or cure of infections will be taken up in the following pages.

The question whether a vaccine or a serum will give better results in the prevention or treatment of a given disease is one that must be worked out by experiment. It has been found that in some diseases vaccines are better, in others sera. It is not possible as yet to protect against all infections by these methods. Tuberculosis, for instance, is a disease for which no reliable method of immunization has been perfected. The prevention and treatment of infections by vaccines and sera is one of the most hopeful developments of medicine, and one which is constantly growing in importance.

The methods of acquiring immunity may be summarized as follows:

1. *Active Immunity.* In this the patient himself produces his own antibodies. He may do this because he has the disease in a mild form (purposely as in smallpox vaccination) or in a severe form (accidentally or naturally) or because he has had the dead germs which cause the disease (or their toxins) injected into him. In the latter case the body reacts just the same as though there were a real infection, but of course the reaction is not so severe and is only temporary because no real infection occurs.

2. *Passive Immunity.* In this the patient takes no part in the formation of the antibodies. Some animal (usually a horse) is purposely made immune by one of the processes of active immunity described above. The animal's serum is then collected. This contains the desired antibodies and when injected into a patient saves the patient from the slow and painful process of forming his own antibodies.

Both of these methods, *Active* and *Passive*, have their advantages and disadvantages.

Active Immunity.—When a person has the actual disease he produces the protective substances under the stimulation of living bacteria, during the height of the disease and in convalescence. When he is injected with a vaccine for protection against a disease he manufactures these substances under the stimulation of dead bacteria, when he is in good health, as a preparation against the time of need. In the first instance he does it under the stress, strain and danger of the actual disease; in the second case he does it gradually, easily, and at his own convenience. In both instances he does the same thing, but certainly the second method is preferable when it is possible and there is time to apply it.

Whether active immunity follows either an attack of the disease or preventive inoculation, *some little time is required to produce the defensive substances*, for the body cells must have time to manufacture them. An *active immunity lasts*, however, for *a long period*, for the rest of one's life after an attack of typhoid fever, for several years after anti-typhoid inoculation.

As yet it is practicable to produce active immunity to only a few infections, the most conspicuous successes being typhoid, diphtheria, smallpox, boils, hydrophobia, scarlet fever and one or two others.

Passive Immunity.—Active and passive immunity are of equal value, but for different purposes. *Broadly speaking, active immunity is for prevention, and passive immunity for cure.* When a patient is already sick, there is not time for him to acquire an active immunity; he wants *immediate passive* immunity.

The protection given by animal serum is, however, short, lasting only a few weeks. This is what would be expected, as the cells of the patient's body have taken no part in the process. Sera are not, therefore, well adapted to *protecting* healthy persons against a disease, although diptheria and tetanus (lockjaw) and one or two other antitoxins are give when there is *immediate* danger that a person may develop the disease.

The protection given by sera is *immediate;* they have, therefore, extreme value when a person has already contracted a disease. They have given him *immediate* help by providing him with *ready-made* defensive substances. By the time the antibodies in the sera are used up, the patient himself, *if he had the disease*, has produced a sufficient quantity, and he therefore has the benefit of his own, *prolonged*, *active immunity.*

CHAPTER VII

PREPARATION AND NATURE OF THE MATERIALS USED FOR PRODUCING IMMUNITY

I. Sera.—The most widely used sera are those against the diphtheria and tetanus (lockjaw) bacilli, menigococci (the cause of cerebrospinal fever), scarlet fever streptococci and pneumococci. Innumerable lives have been saved by the use of diphtheria, tetanus, and meningococcus sera.

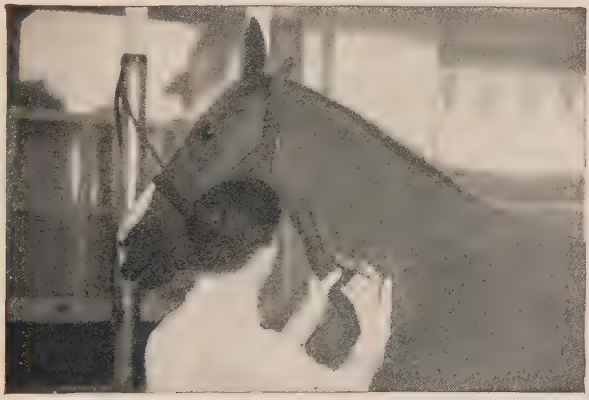

Fig. 14.—Injecting diphtheria toxin (broth in which diphtheria bacilli have grown) into the jugular vein of a horse. Observe that the horse is not being hurt (Courtesy of H. K. Mulford Company, Philadelphia).

At the present time scientists are making great advances in preparing and improving sera against other infections, and the use of this form of treatment will undoubtedly become more general in the future.

The usual method of making therapeutic sera is as follows: A horse is injected subcutaneously, at intervals of five to seven days, with gradually increasing amounts of broth in which the desired germs have grown, and which contains their toxin (Fig. 14). The horse is the animal chosen because it yields a large amount of blood on account of its size. The first dose is very small, not enough to make the animal sick; but at the end of the treatment it may take, without symptoms, many times what would have been a fatal dose at the beginning. At the end of three or four months, when

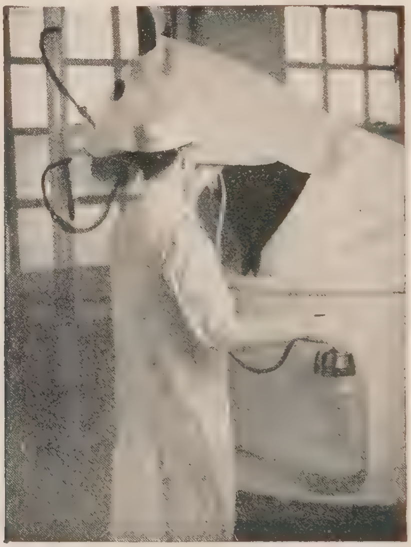

FIG. 15. -Bleeding from the jugular vein a horse that has been injected with diphtheria toxin. The blood contains diphtheria antitoxin. Note the aseptic technic. The site of the operation has been shaved and treated with antiseptics. As much care is exercised to avoid infection as in operations on human beings (Courtesy of H. K. Mulford Company, Philadelphia).

the horse has developed a large amount of antitoxin in its blood, it is bled with aseptic precautions from the jugular vein, 6 to 8 quarts of blood being removed at one time (Fig. 15). The blood-serum separates from the clot on standing and is the "antitoxin" used in medical practice (Fig. 16). The horse is given further treatment at intervals, and is bled about once a month as long as it continues to furnish a high grade of antitoxin, which period varies from six months to several years. The horses which are used for the production of diphtheria antitoxin and other curative sera are kept under the best hygienic conditions and remain well and comfortable throughout the treatment.

FIG. 16.—A laboratory in which the serum containing antitoxin is refined and concentrated. The material in the glass jars is serum in various stages of preparation (Courtesy of H. K. Mulford Company, Philadelphia).

Sera must be kept in a dark, cool place, as they gradually lose their strength when exposed to light and warmth. Under good conditions they may keep their strength for as long as a year.

Convalescent Sera. The serum of convalescent patients is sometimes used for the prevention and cure of disease. This is done in the case of diseases the organisms of which have not been discovered, as measles, anterior poliomyelitis, lethargic encephalitis, and chickenpox. The principle underlying the use of convalescent sera is the same as that underlying the use of animal sera, namely, that they contain protective substances against the organisms of the disease. (Fig. 17.)

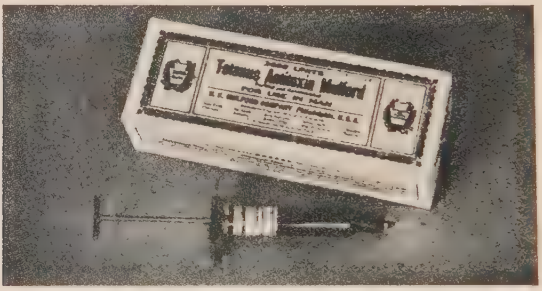
Tetanus Antitoxin Mulford
FOR USE IN MAN
H. K. MULFORD COMPANY Philadelphia, U.S.A.

FIG. 17.—A package of tetanus antitoxin. Various sera are supplied in outfits of this kind. A single dose of serum is put up in an aseptic glass piston syringe and the needle is also sterilized (Courtesy of H. K. Mulford Company, Philadelphia).

II. Bacterial Vaccines.—*A bacterial vaccine is a suspension of dead bacteria in salt solution.* Vaccines are used for both the treatment and the prevention of disease. The procedure in either case consists in giving the person injections of dead bacteria of the kind causing the infection, or against which it is desired to protect. Thus, if the infection is due to the staphylococcus, killed staphylococci are given; if to the colon bacillus, killed colon bacilli, etc. If it is desired to protect the person against typhoid bacilli, dead typhoid bacilli are given. If the bacteria used in making the vaccine have come from the patient himself, the vaccine is said to be *autogenous* (from two Greek words: auto, meaning self, and gen, source); if from some other source, it is called a *stock vaccine*. The treatment by bacterial vaccines, although often spoken of as "vaccination," is entirely different from the *true vaccination* against smallpox, and the use of the same word for both is unfortunate.

It seems strange at first thought that the very germs which are causing the infection can be used for their own destruction. The explanation, however, is that, as was said in the last chapter, the presence of bacteria in the body stimulates it to produce antibodies, that is, substances which are injurious to the bacteria. Dead bacteria as well as live ones stimulate the production of these substances, but they do not cause the disease. They give the protection which is acquired by recovery from the infection without all the disadvantages that go with the actual disease.

Preparation. An autogenous vaccine is made as follows: A culture is taken from the place of infection (an abscess, infected wound, urine in cases of inflammation of the bladder, etc.). The organism causing the trouble is grown in large quantities. At the end of from twenty-four to forty-eight hours the bacteria are put into normal salt solution and are killed by heat or an antiseptic. The number of germs in each cubic centimeter is determined. Usually it is necessary to add more salt solution so that the vaccine contains the desired number of bacteria (usually 500,000,000 or 1,000,000,000 per cc.).

Administration. Vaccines are given in the same way as ordinary hypodermics. The upper arm, shoulder, thigh, or buttock are the usual places for injection. The skin and syringe should be prepared as for any hypodermic injection. The vaccine must be thoroughly shaken before use, as the bacteria settle to the bottom on standing. Many millions of organisms are given at a single dose.

Vaccines should be kept in a cold dark place. Under these conditions they will keep their strength for several months. Aseptic precautions must be used in opening a bottle of vaccine.

Prophylactic Use of Vaccines. The widest field of usefulness for vaccine is not for the treatment but for the *prevention of diseases.* The vaccine most generally and successfully used is that for the prevention of typhoid fever. Prophylactic immunization was used by Pasteur to protect sheep and chickens against certain diseases, and the vaccination of animals against some of the diseases peculiar to them has been a well-recognized practice in veterinary medicine for many years.

III. Vaccination against Smallpox.—We have seen that there are three methods of producing immunity. Two have already been described. We now come to the third, which is the production of the disease in a mild form by giving attenuated or weakened germs to the patient. The two diseases most commonly combatted by this method are smallpox and hydrophobia.

The *principle* of vaccination against smallpox is quite complicated, but it may be stated in a general way as follows: the organism which causes smallpox in human beings also produces in cows a mild disease called cowpox, which appears as an eruption on the udder. In some way which is not understood smallpox, when inoculated into cows, changes its character and becomes a mild disease. When the organisms of this disease are transmitted back again to man, as is done in vaccination, they cause, not smallpox but the mild, non-contagious condition seen in vaccination. This is, however, sufficient to give protection from smallpox for a number of years. The relationship between cowpox and smallpox, and the fact that inoculation with matter from the eruption of cowpox would protect against a later inoculation with the virus of smallpox, were demonstrated by *Edward Jenner*, an English county doctor. He published his observations in 1798, after he had been studying and experimenting on the subject for twenty years. Jenner noted that persons working around cows which had cowpox developed sores on their fingers like those on the cow's udders, and that these persons never caught smallpox during an epidemic. He introduced on a large scale the practice of inoculating people with the material from the eruption of cowpox, which, in an improved form, is what we now call vaccination. To Jenner, therefore, belongs the credit of giving vaccination to the world. Jenner checked his procedures by scientific methods and experiments. His work was *one of the greatest discoveries in medicine.* Vaccination is now a simple preventive measure within the reach of all. It is taken so for granted nowadays that we are in danger of forgetting how valuable the protection is. Without it, smallpox would be just as frequent and virulent as it ever was.

Vaccination (vacca=Latin for cow) is thus the transference of the virus from the skin eruption of an animal having cowpox into the skin of a human being, for the purpose of preventing smallpox. It is an active immunity produced by the introduction of living organisms. It is therefore entirely different in principle from immunization with bacterial vaccines, in which the organisms injected have been killed, or immunization with sera, in which no organisms are injected but the blood serum of an immunized animal.

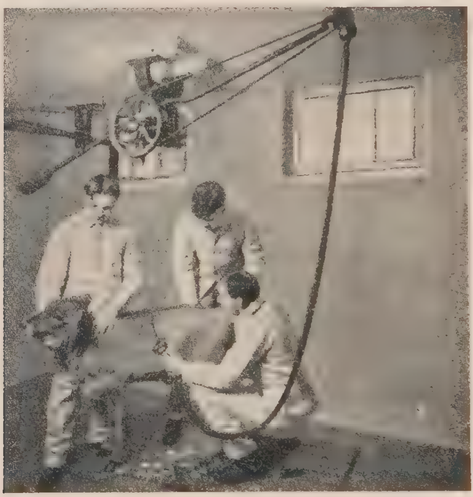

Fig. 18.—Preparing a calf for vaccination. The animal is washed, the long hair clipped, and the skin scrubbed with bichlorid solution. The antiseptic is removed with sterile water and the surface to be operated on is shaved (Courtesy of H. K. Mulford Company, Philadelphia).

Vaccine virus is prepared by inoculating perfectly healthy calves with living organisms either from an animal previously inoculated with vaccine virus or from a human vaccination sore. The skin of the abdomen and inner side of the thighs is shaved (see Fig. 18) and sterilized, and slight scratches are made in parallel lines over this area. The virus is rubbed into these scratches, after which the skin is dressed with sterile gauze and cared for with aseptic precautions. In a few days the calf develops sores similar to those following vaccination in human beings. The material from these is scraped out and worked up with glycerin (see Fig. 19). One calf yields enough virus to vaccinate 1500 persons. Freshly prepared vaccine always contains bacteria. It is therefore allowed to stand for three or four weeks, by which time the gylcerin has usually killed all the bacteria. It is not put into tubes, however, until it has been tested and found to contain no bacteria. It is also tested for its vaccination power by animal experimentation. A single dose of virus is put up in a small tube, which is washed with alcohol before use, broken with sterile gauze, and emptied by

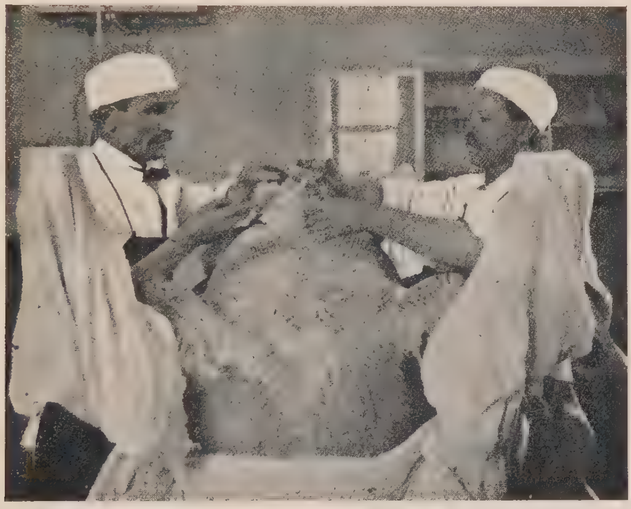

FIG. 19.—Removing the virus from the lines of the vaccination eruption (Courtesy of Parke, Davis & Company, Detroit).

means of a small rubber bulb. The virus must be kept cold until it is used.

Hydrophobia Virus.—The organism causing hydrophobia is still imperfectly known. We do know, however, that it localizes in the tissues of the brain and spinal cord and that the disease may be transmitted by injections of the fresh brain or spinal cord of an animal dead of hydrophobia.

If, however, the brain or cord be allowed to dry out partly, the organism is so weakened that, although it cannot cause the disease, it may still stimulate the production of antibodies.

The Pasteur treatment for rabies (hydrophobia) consists of a series of injections of partly dried spinal cord of rabbits dead of rabies. It is a great boon to mankind, since rabies was formerly a prevalent and much dreaded disease.

Recently experiments have been tried in which dead, instead of merely weakened, organisms have been used to immunize to rabies. There is evidence that such a method may be better than the older one devised by Pasteur. (See also Chapter XXI.)

CHAPTER VIII

TRANSMISSION OF DISEASE

How Bacteria Are Cast Off from the Body.—There are certain definite pathways, as we have seen, by which germs enter the body. There are also certain definite ways in which they leave the body. They are cast off in the *excretions* and *secretions*, the most important of which in this connection are the feces, urine, sputum, nasal discharge, saliva, pus, discharges from ulcers, wounds, sores, infected eyes, etc. The particular excretion in which the bacteria causing the infection appear depends on the disease. In diseases affecting the intestines, as typhoid fever and dysentery, they are present in the bowel movements. The urine contains bacteria from infections of the kidneys and bladder; also those of some other diseases, notably typhoid fever. In infections of the lungs—for example, consumption and pneumonia, whooping cough and influenza—the sputum contains the bacteria causing the conditions, sometimes hundreds of millions being thrown off in a single day. The saliva is infectious in diseases of the throat also, as tonsillitis and diphtheria. The nasal secretion contains the disease organisms in common colds, grippe, and also in measles, and usually also contains germs from lungs and throat. It is very important for the nurse to know the particular way in which the germs are cast off in each infection, so as to guard against spreading the disease through the discharges.

How Bacteria Are Transferred from One Person to Another.—Most disease-producing organisms die rapidly in the outside world, and multiplication outside the body occurs only in the case of a few, such as the growth of typhoid or diphtheria bacilli in milk. Disease germs, therefore, pass from one person to another either directly or with only a short stay outside the body. The most important way in which infection is transmitted is by directly touching the excretions of the infected person, or *indirectly* by touching things that have been recently contaminated with them. For example, the germs of diphtheria, tonsillitis, or a common cold may be transferred *directly* from one person to another by kissing on the lips. Syphilis and gonorrhea are examples of diseases commonly transmitted by direct contact with an infected person. They may be transmitted *indirectly* by a pencil or by chewing gum or any other article which goes from the mouth of an infected person into that of a normal one. A nurse may get typhoid fever or dysentery by soiling her hands with the bowel movements of a patient and neglecting to scrub them before going to her meals, the bacilli being transferred *directly* from patient to nurse.

If the typhoid bacilli get into a water supply, a single patient may indirectly, through the water supply, be the cause of hundreds of cases in a city a long distance away. Many other examples of ways in which bacteria may be carried from person to person, either directly or indirectly, will occur to every one. If the sputum of a pneumonia or tuberculosis patient is allowed to dry, the germs causing these diseases may be blown into the air and spread around. Only a few bacteria have the power of motion, and that only in liquids, and *no bacteria can rise from a moist surface.* They are merely carried passively from one person or thing to another. Even when the method by which an infection is spread seems almost impossible to explain, some unsuspected point of actual contact will be found.

Contact Infection.—Genuine contact infection occurs only when one comes into *direct, personal contact* with an infected person. Examples of this are infection transmitted by kissing, sexual intercourse, etc.

Droplet infection, in which the bacteria are thrown out in coughing and sneezing, is a special form of contact infection, as the organisms pass directly from one person to another. When a person coughs or sneezes "into the open," bacteria are thrown into the air for two or three feet in droplets of saliva and mucus. These droplets are so light that they may remain in the air for a considerable time, and *they may be blown many feet by drafts.* This is undoubtedly an important way of spreading the organisms of colds, influenza, pneumonia, whooping-cough, tuberculosis, scarlet fever, diphtheria, and measles. Aside from these special conditions of bacteria-laden dust (dust always contains germs) and spray from coughing or sneezing, the organisms in the air can be disregarded from the standpoint of disease.

Indirect Infection.—*Objects which are likely to carry disease* organisms are those which have come into close contact with an infected person, as bed and body linen, handkerchiefs, drinking cups, tableware, and toys. Things which have not been in contact with the patient, as floors, walls, furniture, curtains, etc., are unlikely to be the means of transmitting disease germs. In the control of infectious diseases we are growing more and more particular in the care of the patient's discharges and paying less attention to his surroundings. We are all very careless in our habits in regard to saliva, far more so than we like to realize. The case has been stated vividly by a physician: "If infection by contact is of such very great importance in the fecal-borne diseases, how much more important must it be in diseases in which the infective agent is found in the secretions of the nose and mouth, as is the case with diphtheria, scarlet fever, small-pox, mumps, measles, whooping-cough, tuberculosis, influenza, and cerebrospinal meningitis. Every one avoids feces and urine, but it is only the very few who have any objection to saliva.

"Not only is the saliva made use of for a great variety of purposes, and numberless articles are for one reason or another placed in the mouth, but for no reason whatever, and all unconsciously, the fingers are with great frequency raised to the lips or to the nose. Who can doubt that if the salivary glands secreted indigo the fingers would not continually be stained a deep blue, and who can doubt that if the nasal and oral secretions contained the germs of disease, these germs would not be almost as constantly found upon the fingers? In this universal trade in human saliva the fingers not only bring the secretions of others to the mouth of their owner, but there, exchanging it for his own, distribute the latter to everything that the hand touches. This happens not once, but scores and hundreds of times during the day's round of the individual. The cook spreads his saliva on the muffins and rolls; the waitress infects the glasses and spoons; the moistened fingers of the peddler arrange his fruit;

the thumb of the milkman is in his measure; the reader moistens the pages of his book; the conductor his transfer tickets; the lady the fingers of her glove. Every one is busily engaged in this distribution of saliva, so that the end of each day finds this secretion freely distributed on the doors, window sills, furniture and playthings in the home; the straps of trolley cars; the rails and counter and desks of shops and public buildings; and, indeed, upon everything that the hands of man touch. Besides the moistening of the fingers with saliva and the use of the common drinking cup, the mouth is put to numberless improper uses which may result in the spread of infection. It is used to hold pins, string, pencils, paper, and money. The lips are used to moisten the pencil, to point the thread for the needle, to wet postage stamps and envelopes. Children 'swap' apples, cake and lollipops, while men exchange their pipes, and women, hatpins. Sometimes the mother is seen 'cleansing' the face of her child with her saliva-moistened handkerchief, and perhaps the visitor is shortly afterward invited to kiss the little one" (Chapin).

These habits are responsible for an immense number of infections, and yet it is extremely difficult to break ourselves of them. As a matter of fact, the diseases which are spread through the feces (typhoid, dysentery, and the summer diarrhea of infants) have decreased rapidly in recent years owing to public health measures. Diseases spread through discharges from the mouth are much more difficult to control, and with some of them, as pneumonia, influenza, scarlet fever, and measles, public health methods have as yet made little advance.

Insect Carriers of Disease.—*Bacteria are carried by insects.* Among the important insect carriers are common house flies and certain mosquitoes. *Flies* may distribute bacteria over food by crawling on it. These insects are attracted not only to food but to filth of all kinds, particularly feces, and from the latter may carry germs on their feet to the table. The eggs (see Fig. 20) of the fly are laid in manure or garbage and require about ten days to grow into flies. The insect has a very keen sense of smell and is attracted to all kinds of filth and also to food. It goes from feces,

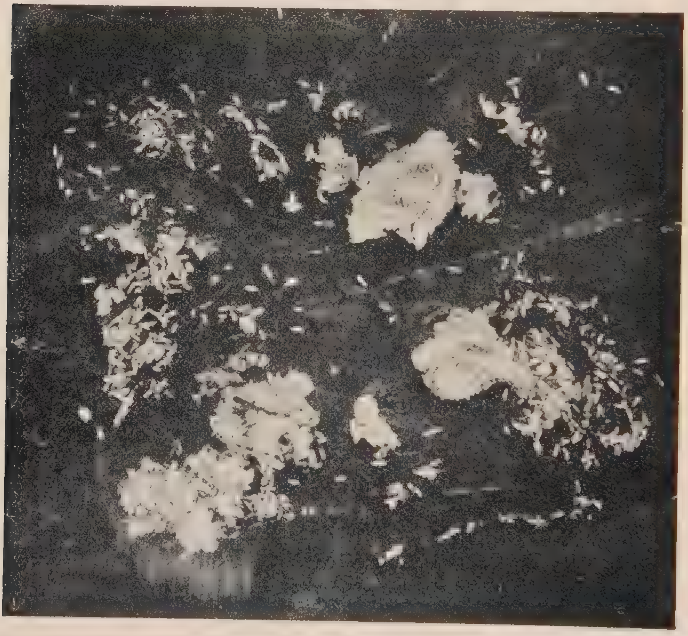

FIG. 20.—Eggs of the house-fly on the surface of a manure pile. Natural size (From Newstead).

perhaps of a typhoid or dysentery patient, to the dining room, where it drops into the milk or crawls over the butter. It has tiny hairs (see Fig. 21) on its legs which wipe upon the feces or other material over which it travels. The fly also eats the filth over which it passes and excretes it again from its intestine as fly-specks. It is no wonder that campaigns against flies have been undertaken in the last few years by progressive communities.

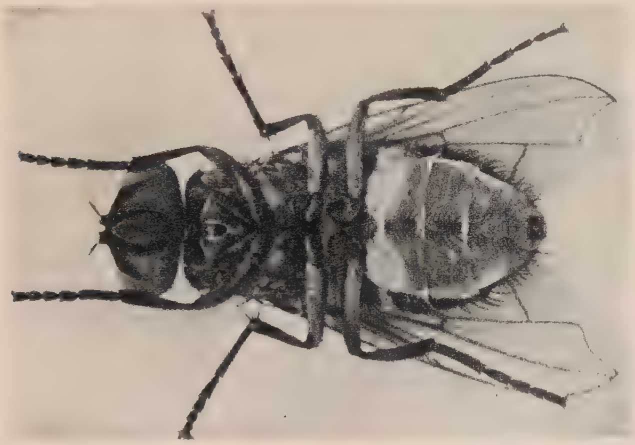

FIG. 21.—The house-fly, under surface. Note the hairs on the legs and body (Photograph by N. A. Cobb. Copyright by National Geographic Society of Washington, D. C.)

The reduction of flies is an important sanitary measure. Pits in which manure is deposited should be screened. Garbage should be kept tightly covered and should be collected frequently. No accumulations of filth of any kind should be permitted. Toilets, kitchens, and dining rooms should be thoroughly screened. Food exposed for sale should be protected by netting or glass during the fly season. As to the actual killing of flies, it is particularly important to destroy the *first ones of the season.* (See also Chapter XXII.)

Mosquitoes. Mosquitoes of certain species transmit malaria and yellow fever. Their relation to these diseases are discussed in the sections on malaria and yellow fever respectively.

Summary.—A general viewpoint, of fundamental importance, which has been gained from our study of disease germs is this: we must not think of them as scattered broadcast over the earth. They are not. They are limited to *infected persons* and *to things which have been recently contaminated* with their excretions and secretions. It is the *infected person* that is the center for spreading organisms, and the way he does it is *by actual contact* with another person or *through articles or insects soiled with his excretions. Disease germs remain closely associated with infected persons.*

The number of infections arising in a ward where there are chronic patients is, to a large extent, a measure of the cleanliness of the conditions in the institution and of the carefulness of the nursing. A number of cases of sore throat, dysentery, or pneumonia occurring one after another in a ward means that the germs are being passed around in some way that could be prevented by suitable measures. In the case of dysentery it may be that there are carriers of the germs, who are helping to prepare or serve the food, or that the feces of dysentery patients have not been protected from flies and the latter are contaminating the food. In the case of sore throat, patients may be using towels or drinking cups in common, or the dishes which they use may not have been thoroughly washed. It requires constant watchfulness on the part of the nurse to guard against the transfer of bacteria from patient to patient in a ward.

CHAPTER IX

SANITATION

Rules for Nurses.—The chief ways in which bacteria are carried around a ward have been summed up as "food, fingers, and flies," and the most important of these is fingers. The nurse must train herself so that it is second nature for her to wash her hands thoroughly after handling bedpans or anything dirty, and always before preparing the patient's food or going to her own meals, and never to touch any contaminated thing unnecessarily. If it is necessary to bring the hands into contact with infected material, rubber gloves should be worn.

In mental hospitals, patients who help serve the food should be made to wash their hands before going into the dining room, and no patient who is not neat should be allowed to assist.

Bedpans, sputum cups, and soiled dressings should be kept covered and disposed of as soon as possible. All articles contaminated by patients' excretions should, of course, be disinfected.

As to the prevention of infection of the nurse herself, it is a good rule to remember while on the ward never to put the fingers near the face, and to scrub and disinfect the hands thoroughly on leaving the ward.

When bacteria go directly from person to person they are more likely to be virulent than if they have existed for some time in the outside world. Typhoid bacilli passing immediately from the patient's feces through soiled hands into another person's mouth would be more likely to cause typhoid fever than the same organisms after they had grown for some months in the laboratory.

Disinfection and Sanitation in Infectious Disease.—There are two kinds of disinfection necessary in infectious diseases: that carried on *during* the course of the disease, and that which takes place *after* it has ended. They are called *continuous* and *terminal disinfection* and the first is the more important.

Continuous disinfection means the immediate disposal of contaminated articles before the germs have a chance to be distributed; for instance, the burning of gauze handkerchiefs soiled with secretions from the mouth and nose, boiling dishes, soaking the bed and body linen in disinfectant solution, disinfecting the stools in infections of the intestine. The place where disinfection does the greatest amount of good is at the bedside, and as soon as possible after the excretions have been passed. This disinfection is the duty of the nurse, and it is just this painstaking, individual work that is of the greatest importance in stopping the spread of infections. Every nurse who carries it out conscientiously, intelligently, and thoroughly, either in the hospital or in the private home, may feel that she is protecting the community and making an important contribution to public health.

By *terminal disinfection* is understood washing the woodwork, furniture, and all exposed surfaces with hot soapy water, wiping with a disinfectant solution, if possible putting on fresh paper and paint, airing the room for several days, and disinfecting the mattress and blankets *after the termination of an infectious disease.* The more carefully the patient has been taken care of during the disease, the less necessity is there for terminal disinfection.

"It is quite as important to know what to disinfect, as how to disinfect and when to disinfect." The only way to know what to disinfect is to know, for each infection, how the organisms causing it are cast off, how long they remain alive outside the body, and how they enter the body to produce the disease. We shall take up these points for each organism considered in the following chapters.

If strict precautions against the transfer of germs are taken, different contagious diseases can be cared for in the same ward, and no patient will catch the disease of another. This is a test of the intelligence and carefulness of the nursing. In many infectious disease hospitals two or three different diseases are treated in the same ward. The beds are separated by low partitions, merely as a reminder and to prevent droplet infection, and there are arrangements for washing the hands in each compartment.

Disinfection and sanitation in infectious diseases must often be carried beyond the ward or sickroom. *Carriers.* A person who has recovered from an infectious disease may *continue to give off the germs of the disease for months,* or even years, afterward. It is also true that persons who have been in *close contact* with those suffering from an infectious disease, as nurses and members of the family, may acquire the germs and yet not develop the disease. About 3 per cent of those who have had typhoid fever continue to pass typhoid bacilli in the feces, and persons who have been associated with diphtheria cases often have diphtheria bacilli in their own throats, and still remain well.

Persons who, although showing no signs whatever of disease, harbor and disseminate pathogenic organisms, are called "carriers." Carriers have often proved to be the cause of outbreaks of different infections and, in fact, stand next in importance as a means of spreading disease to actual contact with a patient. They may be even *more dangerous than the patient* because they come in contact with more people and *no one suspects them.*

Contact with an unrecognized carrier explains the origin of many apparently mysterious cases of infectious diseases in which the patient is not known to have come in contact with another case of the infection. Only a very few carriers in any community are ever discovered, usually only those who have infected other persons; the vast majority are never suspected. Not only typhoid and diphtheria, but dysentery, pneumonia, cerebrospinal meningitis, infantile paralysis, and many other diseases are spread by carriers. The only way to tell whether a person is a carrier is to examine him for the particular germ suspected; for example, to take material from the throat of a possible diphtheria carrier, and from the feces for typhoid or dysentery and examine it in the bacteriological laboratory. The importance of carriers in spreading infection is being realized more and more. We shall discuss them more fully in connection with the diseases studied in the following chapters. (See also Section III, "The Prevention of Disease.")

Sanitation in the Operating Room. Aseptic Technic.—In so-called clean surgical cases, in which there is no infection before operation, germs may be carried into the wound on the hands of the surgeon. They may be carried into the wound on instruments or dressings which have not been perfectly sterilized, or which have been contaminated after sterilization. Germs from the patient's own skin, which has not been thoroughly disinfected before operation may also cause infection of surgical wounds. The whole object of *aseptic technic* in surgery is to *keep the wound free from microörganisms*, and this demands

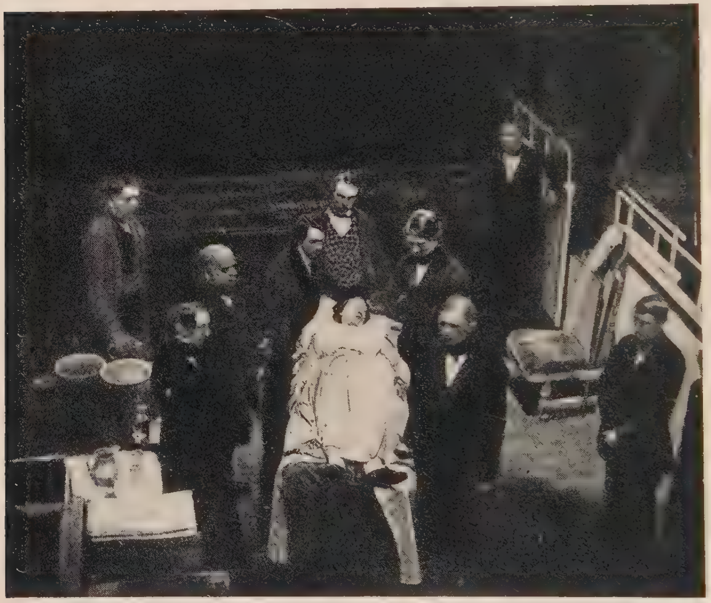

FIG. 22.—How an operation was performed in the days before asepsis. The patient has a tumor of the jaw. This picture is of great historical interest, as it shows the first public demonstration of ether anesthesia in the Massachusetts General Hospital, October 16, 1846 (Reproduced from "The Influence of Anæsthesia on the Surgery of the Nineteenth Century," by J. Collins Warren, M. D.).

teamwork on the part of the surgeon, the assistants, and nurses. It begins with *preparation of the patient* in the ward and the *sterilization of dressings and instruments.* In the operating room it is now common practice to shave the area, if necessary, and paint well with iodine or other suitable disinfectant.

A patient who vomits after ether may draw saliva containing disease germs into his trachea and lungs, and thus develop pneumonia. He infects himself from the bacteria present in his own mouth before operation. It is desirable, therefore, before an operation to have the teeth and mouth clean and to use an antiseptic mouth wash. "The aseptic chain is composed of many links, the breaking of any one of which may lead to disaster." Infection following operation *on a clean case* shows that there has been carelessness on some one's part either in preparation for, or in carrying out, the operation (see Fig. 22).

Responsibilities of the Nurse.—It is absolutely necessary for the nurse to learn to carry out aseptic technic strictly. This requires, in the first place, undivided attention to the matter in hand, for it is in moments of carelessness that breaks occur and the sterile object touches something unsterile. It requires in the second place the development of "*the aseptic conscience,*" a conscience that will not allow the nurse to cut short the time for sterilizing instruments or scrubbing her hands. A nurse should learn to correct her own breaks in technic and the mistakes which no one but herself has observed. She should re-disinfect her hands even if they have barely touched something unsterile. She should discard a dressing or put an instrument back in the kettle if there is the slightest suspicion that it has become contaminated. *A good aseptic technic is one of the surest signs of a well-trained nurse,* and is necessary not only in surgery and obstetrics but also in the care of infectious diseases.

The hands of the surgeon, the assistants, and the nurses are most frequently responsible for wound infection. The most essential part of the sterilization of the hands is thorough *scrubbing in hot running water with soap and sterile brush.* This is much more effective in disinfecting the hands when combined with the use of antiseptics. Scrubbing and disinfecting the hands is not a mere ceremony, but an important matter of business, to which undivided attention should be given.

CHAPTER X

SANITATION (*Continued*)

Sanitation of Food.—Disease germs enter the gastro-intestinal tract by means of contaminated food and drink. Food may be prepared or milk handled by persons who have on their hands the germs of typhoid or dysentery, and the bacteria are thus transferred to the food. Similarly, if food is prepared or handled by a consumptive, the tubercle bacilli may be transferred from the hands, contaminated with sputum, to the food. The importance of clean hands in the cooking, handling, or serving of food cannot be too much emphasized. The hands should always be washed thoroughly before preparing or serving a meal. Many cities require that all applicants for places as *food handlers* in hotels and restaurants be examined for general cleanliness, typhoid, tuberculosis, and syphilis, and that only those who pass the test satisfactorily be employed.

Types of Disease Spread by Food.—Most foods serve many bacteria very well as breeding places. There are three ways in which bacteria in food may cause disease. They may be tabulated as follows:

1. Bacteria may cause partial decomposition or putrefaction in food which may give rise to more or less severe, but usually temporary, disturbances of the stomach and intestines. Such disturbances are often spoken of incorrectly as "ptomaine poisoning." It is not at all certain, that such a thing as actual "ptomaine poisoning" really exists.

2. Bacteria known to cause infectious disease may get into the food by one of the methods indicated in this chapter. Typhoid and paratyphoid bacilli and dysentery germs are particularly frequent as causes of *food infection.*

3. True *food poisoning* by bacteria is due to the growth in the food of an organism called Bacillus botulinum which secretes an exo-toxin into the food. This germ will be discussed later on.

How to Guard against Food Infection and Food Poisoning.—Thorough cooking of food is a great safeguard against any harmful bacteria that may be present, but cooking to the point of sterilization is difficult in the case of large masses of food, as the *heat penetrates very slowly.* The outside of a roast or the top of a pudding may be browned, and yet the center may never be more than lukewarm. Steaming or boiling is more effective in sterilizing food than baking or frying. The thrifty housewife heats, and thus sterilizes, left-over food which she is afraid will not "keep" until it can be eaten.

Food poisoning by B. botulinum is usually a fatal disease. It may very easily be guarded against, however, by heating all canned foods to boiling for a few minutes. This destroys the toxin formed by the germ. The modern improvements in the methods of canning foods have practically eliminated the danger of food poisoning.

The cleanly preparation and serving of food is of great importance, both from the standpoint of general decency and also as a protection from disease. The first essential is clean hands, for bacteria, either harmful or harmless, are easily transferred from them to food.

A few bacteria thus planted on food or in milk may increase enormously under favorable conditions. This will be further considered when we discuss typhoid and dysentery. The problem of clean hands is a pressing and difficult one in institutions like state hospitals where the patients help in kitchens and dining rooms. Bacteria may also be carried onto food by rats, mice, bugs, and flies.

The protection of clean food from contamination by handling, flies, etc., is an excellent bacteriological precaution. The wrapping of bread at the bakery, and the serving of milk in bottles at restaurants are examples of this.

The *method of dishwashing* also has bacteriological importance. Washing dishes in a pint of lukewarm water with a dirty mop merely distributes bacteria over them. An abundance of *scalding water* should be used with *strong* soap. The proper washing of spoons, forks, and dishes that touch the mouth is especially essential. Clean dishwashing is of much importance wherever many people are fed—as in hospitals, institutions, or restaurants—for a poorly washed spoon or fork may be the means of carrying disease germs, like those of pneumonia or influenza, from one person's mouth to another's. Machine dishwashing is far cleaner than that done by hand. In infections transmitted by saliva and sputum, the dishes and eating utensils of the patient should be *boiled.*

Milk.—Bacteria of most kinds grow well in milk, which contains more organisms than any other kind of food. Mere numbers of bacteria, however, are not alarming; it is the kind that is important, and fortunately those in milk are usually harmless.

Milk as it is drawn from a healthy cow contains a few germs, but it acquires many more from the cow's body, the dust and dirt in the barn, the hands of the milker, etc. Some of this contamination is unavoidable, but it can be greatly reduced by care in the cleanliness of the cows, milkers, barns, cans, etc., such as is now observed in all good dairies. When it has just been drawn, very clean milk contains about 100 bacteria to each cubic centimeter. By the time milk reaches the city customer, from 24 to 48 hours later, the number of bacteria ranges from about 3000 per cubic centimeter in the very best milk to millions in a cubic centimeter

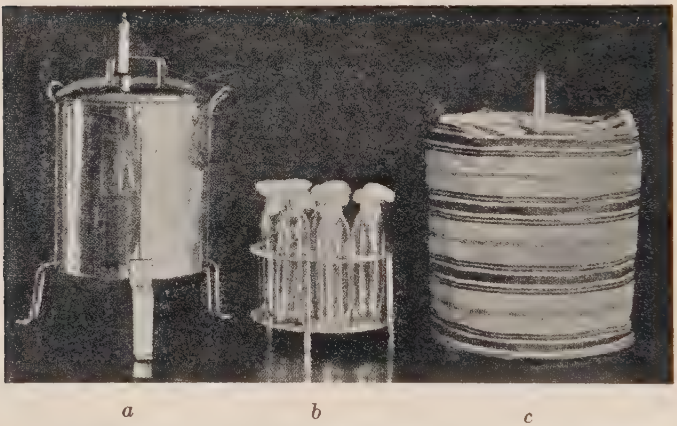

FIG. 23.—Pasteurizer for baby's milk. *a*, Sterilizer and thermometer. *b*, Stand for tubes. *c*, Sterilizer covered with cozy after removal from heat. The bottles are put in the kettle, which is filled with cold water up to a level with the milk in the bottles. The kettle is heated on the stove until the thermometer in the water reaches 145° F. The kettle is then removed from the stove, covered with a blanket, and allowed to stand for thirty minutes. The bottles are then taken out, quickly cooled in running tap-water, and then placed on ice until used (From Pediatrics, vol. i, by Dr. Charles Hunter Dunn).

of bad milk. Good, average grade milk contains about 50,000 bacteria in a cubic centimeter. These bacteria are usually harmless in themselves, but the presence of large numbers of them in milk shows that it has either been produced and handled under uncleanly conditions, or is stale and has not been kept cool. It may also have come from cows with abscesses or inflammation of the udder.

Unless one knows, personally, exactly the conditions under which it is produced and handled, milk, especially for infant feeding, should in most cases be pasteurized in the household. A homemade pasteurizer may be arranged with a double-boiler and a thermometer; or, for infant feeding, a large covered kettle in which to set the nursing bottles will suffice, with some device to raise them off the bottom. (See Fig. 23.)

Public Health Supervision of Milk Supply.—Good milk is so important that boards of health in all large cities and most smaller ones regulate the conditions under which it shall be produced and sold. *Supervision of the milk supply* is a part of the work of the health department. The farms on which it is produced are inspected, and sanitary conditions are enforced in the buildings, among the employees, in the care of the cows, and the handling of the milk. Milk from sick animals cannot be used, nor can the milk be marketed if there is a case of infectious disease among the family or employees on the farm. Milk must be kept in the refrigerator in the store and sold only by the bottle. No milk is allowed to be sold which contains more than a certain number of bacteria in each cubic centimeter.

In many communities *milk is graded or classified* according to the conditions under which it has been produced and the number of bacteria which it contains. "Grade A" is produced under exceptionally clean conditions, and is suitable for infant feeding. It may either be pasturized or sold raw, when it is usually "certified" to be pure. "Grade B" is produced under ordinarily good conditions, and may safely be used for drinking by adults. It may or may not be pasteurized. "Grade C" is produced under poor conditions, contains large numbers of bacteria, and should be used only for cooking. In many communities such milk is not allowed to be sold.

In the household, milk should be kept *covered* and *cold.* The mouth of the bottle should be wiped with a clean cloth before the milk is poured out unless the cap fits down over the top. Milk bottles should never be taken into a sick room.

SECTION II

Special Bacteriology

CHAPTER XI

THE MICROCOCCI

In a foregoing chapter we have pointed out that bacteria are divided, according to their shape, into three main groups: the cocci, (spheres) the bacilli (rods) and the spirilla (curved or spiral). It is to the first of these groups that we shall now turn our attention.

Attention has already been drawn to the fact that cocci arrange themselves in different ways as they multiply. Those forming into chains are called *streptococci*, those arranging themselves in irregular clusters like bunches of grapes are called *staphylococci*, while those which form pairs are called *diplococci*. The cocci are classified still further, according to the manner in which they grow in certain media and the changes they induce in certain substances. The micrococci which we shall study in this book may be tabulated for convenience according to their *staining reaction* as follows:

Gram-positive:

- Staphylococcus albus
- Staphylococcus aureus
- Streptococcus hemolyticus (often called beta type streptococci)

  Streptococcus viridans (often called alpha type streptococci)
  Diplococcus pneumoniæ (often called pneumococcus)
Gram-negative: (All of these are diplococci)
  Neisseria gonorrheæ (often called gonococcus)
  Neisseria intracellularis (often called meningococcus)

The staphylococci and streptococci were among the earliest pathogenic bacteria to be discovered. Staphylococci were first cultivated from pus in the laboratory by Pasteur in 1880, and streptococci, by Fehleisen, from erysipelas in 1883. (See Plate II, Figs. 1 and 2.)

The **Staphylococcus albus** is a very common and widespread germ. The syllables "staphylo" come from a Greek word meaning cluster, and the name is given because the cocci grow in groups like a bunch of grapes. It is called "albus" (white) because, when growing on culture media, it forms a chalky white coloring matter. It is widely distributed in the outside world and on the bodies of human beings and animals. It is always present on the skin as a harmless resident, but if the skin is injured through a cut, a scratch, or in other ways, the cocci get into the underlying tissues and may cause an infection.

The Staphylococcus albus grows easily and quickly in the laboratory. It is quite resistant to drying, and can, therefore, remain alive for a considerable time (several months under favorable conditions) outside the body. It is rather a vigorous organism, not easily discouraged by unfavorable conditions. Boiling for 3 minutes, and ordinary disinfectants will kill staphylococci.

A boil is the commonest form of infection in which the Staphylococcus albus is found. Infection of stitches following operation is most frequently caused by the Staphylococcus albus. These infections are commonly called "stitch abscesses." As a rule it does not produce a dangerous inflammation, but in many cases it is very hard to get rid of.

Staphylococcus aureus is, in practically every respect, like Staphylococcus albus. It differs in producing a golden pigment (hence the name aureus) and in being a much more dangerous germ. It causes large boils, carbuncles, sometimes fatal septicemia, and large abscesses in the internal organs and bones, called *multiple abscesses.*

Both types of staphylococci always cause much pus formation. They produce a substance (leucocidin) which kills white corpuscles. It is easy to see that in handling staphylococcus infections, the greatest care should be exercised not to let the pus come into contact with anything which will distribute it. The germs are transmitted only in pus. They are easily killed by boiling since they do not form spores. Staphylococcus infections, such as boils and infected wounds, are often very favorably influenced by vaccine treatment. The treatment has been most successful in chronic infections, such as infected wounds, ulcers, chronic cystitis, and in localized infections, such as "crops" of boils. It is not used to any extent in acute infections.

The Streptococci form a large group or family of organisms, for there are family groups among bacteria, as among the higher plants and animals. The members of a group of bacteria may differ as widely from one another as members of a human family, and this is the case with the streptococci. Some are found in water and milk and are entirely harmless; others live in the human body and give rise to disease. We shall discuss here only the latter.

Streptococci are so called because they grow in chains, "strepto" coming from a Greek word meaning chain. They grow readily in the laboratory on blood or serum media, although they are less hardy then the staphylococci. They are easily killed by heat and antiseptics, but they may remain alive and virulent for some time when dried; for example, in sputum for several weeks.

Types of Streptococci.—We have indicated, at the beginning of the chapter, two types of streptococci. The names of these types are taken from their action on red blood corpuscles. They are distinguished as follows: If a tube of melted agar containing a little blood be inoculated with a few beta type hemolytic streptococci and then poured into sterile plates and incubated for twenty-four hours, the colonies will appear as tiny white specks surrounded by a zone which is *perfectly clear and colorless* (see Fig. 24). These cocci have the power of causing the dissolution of the blood, or *hemolysis* (from two Greek words, hemo = blood, and lys = to dissolve). This type of hemolysis is called the *beta type* (Greek letter β) and the streptococci are said to be hemolytic streptococci of the beta type. They are also spoken of as *Streptococcus hemolyticus*. Under the same conditions, some streptococci produce not only the clear zone but also a greenish zone close in around the colony (see Fig. 25). Sometimes the green, central zone is so wide as to completely obscure the clear zone. Streptococci producing this greenish zone are said to be hemolytic streptococci of the *alpha* (Greek letter A or α) *type*. They are also very widely spoken of as the Viridans (green) type, or *Streptococcus viridans*.

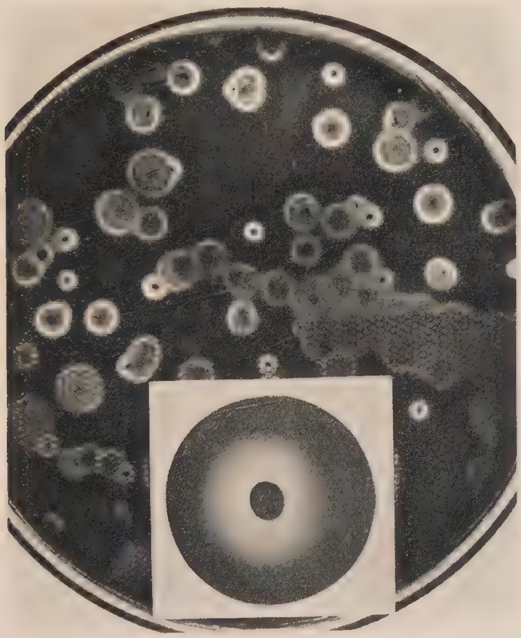

Fig. 24.—Natural size photograph of blood agar plate showing colonies of beta type hemolytic streptococci. Each colony is surrounded by a perfectly clear zone in which all the blood corpuscles have been completely destroyed. The small insert shows one of the colonies much enlarged (Courtesy of Dr. J. Howard Brown, Johns Hopkins University).

Diseases Caused by Streptococci.—The streptococci produce many diseases, most of which take the form of acute or chronic inflammations. Streptococcus infections are usually characterized by having little or no pus, there being merely serum.

The acute streptococcus inflammations are caused almost exclusively by those of the beta type, and the chronic infections by the alpha type. *Scarlet fever, septic sore throat, septicemia, erysipelas, peritonitis, puerperal fever, bronchopneumonia, meningitis* and a number of other acute diseases are caused by beta type hemolytic

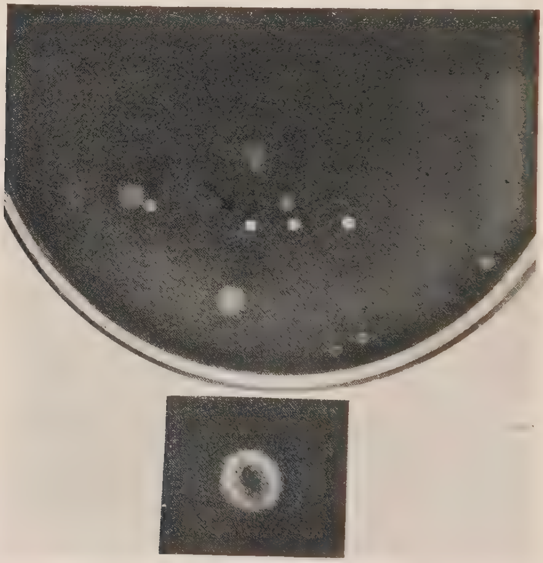

FIG. 25.—Natural size photograph of blood agar plate showing colonies of alpha type hemolytic streptococci. (Streptococcus viridans.) Each colony is surrounded by a small clear zone. In the center, close around the colony is a zone of greenish corpuscles. Sometimes this greenish zone is so wide as to mask the clear part. Often it is so narrow as to be visible only with the microscope as shown in the small insert. The colony may then be mistaken for a true, beta type streptococcus colony (Courtesy of Dr. J. Howard Brown, Johns Hopkins University).

streptococci. *Endocarditis* and *rheumatism* (doubtful), *tooth root abscesses* and several other rather prolonged or chronic infections are caused by the alpha type streptococci.

Infection of the skin and underlying tissues is one of the most frequent and dangerous conditions caused by beta type streptococci. They give rise to a very severe, rapidly spreading infection with much swelling, attended by marked general symptoms. This condition requires immediate surgical attention. The streptococci may enter through a very tiny break in the skin, as, for instance, when a surgeon pricks his finger when operating on a streptococcus case. *Erysipelas* is another form of acute skin infection due to beta type streptococci. A large number of normal persons carry virulent streptococci in their mouths and on their tonsils.

Streptococci of the beta type are the germs most dreaded in surgery and obstetrics for they cause most of the fatal infections after operation and most cases of puerperal fever. The greatest danger in streptococcus infections is that the organisms may get into the blood and cause blood poisoning or *septicemia*. This happens most frequently in the rapidly spreading infections of the skin, and in surgical and obstetrical cases. The onset of septicemia is marked by chills, high fever, and a change for the worse in the patient's general condition.

In confinement cases the bacteria are carried into the uterus from the skin or mucous membrane which has been insufficiently cleansed, or on dressings or instruments that are not sterile, or on the hands of the doctor or nurse, which have not been carefully disinfected.

Such infections are, therefore, preventable in practically every case, but they are all too frequent. In well-managed maternity hospitals serious infections almost never occur after uncomplicated cases, but they do sometimes happen when labor has been complicated and operative interference has been necessary. Every woman should, if possible, go to a hospital for confinement, because not only are there better facilities for treating any emergencies that may arise, but it is easier to carry out aseptic technic there than in the home.

Streptococci of the beta type are the cause of some cases of bronchopneumonia, and it is very probable that a special kind of streptococcus is the cause of scarlet fever. There are no other organisms which cause more varied and more serious damage to the human body than do the streptococci. Infection with these organisms was one of the chief causes of death from disease during the World War, the most frequent forms being the infection of wounds with the streptococcus and the streptococcus pneumonia which complicates influenza and measles.

Streptococci of the alpha type may cause an inflammation of the heart valves called *endocarditis*. This is followed by shrinkage and thickening of the valves which causes them to leak. A streptococcus infection is the most frequent cause of those cases of valvular heart disease which begin in early life. The organisms are carried to the heart valves through the blood, most often from diseased tonsils or teeth. The care which is given children's throats nowadays and the removal of diseased tonsils and teeth in both children and adults is diminishing the number of streptococcic infections of the heart valves. Dentists are always on the watch for abscesses at the roots of the teeth. These may give no symptoms and be found only by the x-ray picture. The streptococci causing such infections are usually of the alpha type.

Bronchopneumonia (see description of *lobar pneumonia* below) is always a serious complication in other diseases. Often it is the condition which determines the fatal outcome, so that it is of the utmost importance to prevent its development if possible. Bronchopneumonia may be caused by one or more of a variety of organisms, among which are streptococci. The streptococci or other organisms causing bronchopneumonia may be in the patient's own mouth, or they may be brought to him from the outside on tableware, dishes, thermometers, or nurses' hands. The germs causing bronchopneumonia may be carried from bed to bed in a ward in this way. It is evident that patients who are especially liable to develop bronchopneumonia—that is, those having chronic diseases or passing through acute diseases—must be protected from both the germs in their own mouths and those from outside. This involves special efforts to keep the mouth clean, the same nursing precautions in bronchopneumonia as in lobar pneumonia, and the greatest care to prevent carrying bacteria from one patient to another.

In handling streptococcus diseases, the infectious matter must be very carefully disposed of so that none of the discharges are allowed to come into contact with the nurse, or other patients, or any articles likely to be touched by them. Further, the discharges and dressings must not be allowed to lie around and become dried since, as we have already said, these bacteria can live for some time when dried and may be blown about in dust. Flies also may walk on such material and then on the face and hands or wounds of a patient.

The infectious discharges differ with the disease. In scarlet fever, bronchopneumonia, sore throat, etc., the throat and nose discharges are dangerous. In erysipelas it is the skin and dressings which are infectious. The mode of transmission of endocarditis and rheumatism is not known.

All streptococci are easily killed by boiling and most disinfectants since they do not form spores.

CHAPTER XII

SCARLET FEVER. PNEUMONIA

Scarlet Fever.—It is extremely probable that scarlet fever is caused by a special kind of streptococcus, of the beta type, which can be differentiated by laboratory tests from the varieties causing tonsillitis, puerperal fever, erysipelas, and other streptococcic conditions. It has been known for a long time that streptococci are constantly present in the throat in scarlet fever, that they are the cause of the complications of the disease, such as inflammation of the ear and of the glands of the neck, and that most of the fatal cases are due to them. Several years ago, however, it was demonstrated by experiment that the streptococcus present in scarlet fever is different from those found in other conditions.

The scarlet fever streptococcus locates in the throat and produces a powerful *exotoxin*, which is distributed throughout the body by the circulating blood. In this respect scarlet fever resembles diphtheria. An *antitoxin* for scarlet fever has been prepared, which is as valuable in the cure of scarlet fever as diphtheria antitoxin is in diphtheria. There is also a test (the Dick test) which shows who is susceptible to scarlet fever. This test is described below. There is also a method of giving permanent protection. Much scientific work is being done on the disease at the present time, and if the new discoveries fulfil their promise, scarlet fever will soon be controlled as successfully as diphtheria now is.

The scarlet fever patient can spread the disease from the time of the very first symptoms, and remains infectious for quite a long time. Convalescents who are released from the isolation too soon may transmit the disease. A patient can spread the disease as long as there is any discharge from the nose, ears, glands, or any other part of the body.

The same nursing precautions must be carried out as in diphtheria in regard to all articles contaminated with secretions from the nose and throat, and the nurse must take the same watchful care of her hands. Infection of the middle ear during scarlet fever accounts for much of the deafness among children. Keeping the nose and mouth clean will help to prevent this complication.

Scarlet fever is spread also by mild, unrecognized cases. Many cases are not noticed and it is these which keep the disease alive in a community and are the starting point of epidemics. The school doctor and nurse are always on the watch for these overlooked cases. Daily medical inspection of schools is the best method of finding them, and follow-up work by the nurse in investigating absent pupils will disclose mild cases at homes who have no physician.

The disease may be spread by dairy milk, in the same way as diphtheria (Chapter XVIII). Pasteurization kills the organisms of scarlet fever.

Ninety per cent of the deaths from scarlet fever occur in children under ten years of age.

Antistreptococcus Serum.—This is prepared by injecting a horse with different varieties of streptococci. It often gives good results, particularly in mild and localized infections, but its action is much less regular and powerful than that of some other sera.

Serum Treatment in Scarlet Fever.—We have already pointed out that an antitoxin for scarlet fever has been developed recently. The method of making it is similar to the procedure followed in making diphtheria and tetanus antitoxin (see Chapter VII). This serum has been used on patients with remarkable results. As a rule the temperature falls promptly, the rash disappears within twenty-four hours, the general symptoms improve, and a child who was admitted to the hospital in a grave condition may the next day be sitting up in bed playing with his toys.

The Dick Test.—The scarlet fever toxin itself can be used in very dilute form to *determine the persons who are susceptible to the disease. A very small amount* of the diluted *toxin* of the scarlet fever streptococcus is injected *into* the skin. If the person *has never had* scarlet fever, or *is susceptible*, a red area, about the size of a quarter of a dollar, appears within twenty-four hours. If the person is *recovering from* scarlet fever, or *has had the disease* in the past, he is not susceptible, the reaction is *negative*, and no red spot appears. This is called the *Dick test* after the two Chicago physicians who discovered it, and it promises to have as great practical value in scarlet fever as the *Schick test* has in diphtheria (see Chapter XXVII). The spot remains for about 1–2 days and then disappears quickly, leaving no scar. The test is perfectly harmless.

Immunity in Scarlet Fever.—It is possible to produce an *active immunity to scarlet fever* by injections of small amounts of the streptococcus toxin into the system at intervals of a week. This promises to be of great value in protecting not only children but also physicians and nurses. Some hospitals are already *examining* their nurses by the *Dick test* and *immunizing* those who give a positive reaction.

These new procedures will give us for scarlet fever what we now have for diphtheria—a *test to determine susceptibility* to the disease, *a method of giving permanent protection,* and *a serum for cure of the actual disease.* It now appears probable that the control of scarlet fever will make great advances within the next few years, as these methods come into more general use.

Pneumococci (Diplococcus Pneumoniae) and Lobar Pneumonia.—Pneumococci were demonstrated in saliva by Pasteur in 1880, but it was not until 1886 that they were proved by other medical workers to be the cause of lobar pneumonia.

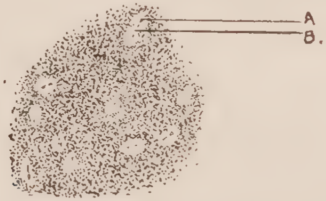

Fig. 26.—Broth culture of encapsulated diplococci (pneumococci) mixed with a little india ink. The tiny black particles are the coloring matter of the ink. "A" is the coccus. "B" is the capsular substance. Magnified 600 times.

The pneumococcus always grows in pairs. (See Plate II; Fig. 3.) It is called a diplococcus (*diplo* is from a Greek word for double). Each pneumococcus of the pair is slightly pointed. Each pair is enclosed in a mucus-like envelope called a capsule. This can be seen under the microscope when stained by a special process. It also appears as a halo around the bacteria if they be suspended in a little india ink and smeared on the slide (see Fig. 26).

The pneumococci produce the same sort of appearance in blood agar as do the alpha type streptococci. They can be distinguished from streptococci by the remarkable property of dissolving when a little bile is added to a broth culture of them. The pneumococcus is a delicate organism, growing with some difficulty in the laboratory. It is easily killed by heat and disinfectants. In dried sputum, however, it can remain alive for a considerable time, from one to two years when protected from air, moisture and light, and as long as nineteen days when exposed in a room. The sputum of a pneumonia patient contains pneumococci in great numbers.

The pneumococci form a family or group of organisms just as do the streptococci. The members of the group differ from one another; some types produce a more severe pneumonia than others. Laboratory examination of a patient's sputum will reveal which variety of pneumococcus is causing the infection. It is important to know this because it gives some idea of how severe the disease is liable to be, and it may help in deciding the treatment, since the kind known as *type I* sometimes yields to serum treatment while the others do not.

A person who has recovered from pneumonia may carry the pneumococcus in his saliva for weeks, or even as long as three months. If such a person coughs or sneezes, without covering his mouth, in a car or theater or any crowded place, or if he handles things with fingers moist with saliva, he will be likely to distribute the germs to his defenseless neighbors, who, in turn, may develop the disease.

Those who have been closely associated with a pneumonia case, as a nurse and members of the family, may also have the pneumococcus in their throats, although they never develop the disease. These persons are *carriers*, as described in Chapter VIII, Sec. I, and they may scatter the germs in the same way as a convalescent from pneumonia. Less is known about pneumococcus carriers than about typhoid and diphtheria carriers; in fact, we are only beginning to learn about them.

There are *three chief ways in which lobar pneumonia is spread:* (1) by the sputum and saliva of a pneumonia patient, (2) by convalescents who still have the germs in their saliva, and (3) by healthy carriers. A fourth but less important means of transmitting the disease is infected dust. Pneumococci have been found in the dust from houses in which cases of pneumonia had occurred. When lobar pneumonia develops it means that the patient has acquired the pneumococci either from a previous case or from a carrier.

Lobar pneumonia is an acute infectious disease. (Note for student: Distinguish carefully between broncho- and lobar pneumonia.) *Lobar pneumonia* derives its name from the fact that one or more entire lobes of the lung become infected at the same time. It is practically never caused by any germ but the pneumococcus. *Bronchopneumonia* may be caused by any one of a number of organisms but particularly by streptococci. It localizes in *patches scattered* throughout the lungs.

The nursing of a case of pneumonia should be that of a communicable disease. Each case must be regarded as a possible starting point for other cases, and every opportunity for the infection of others must be avoided. The sputum should be received in paper cups and burned, together with the gauze or paper handkerchiefs used by the patient. The greatest precautions must be taken to disinfect everything soiled by sputum and saliva. The sterilization of dishes, tableware, and thermometers is especially important. The patient's mouth should be kept clean and an antiseptic mouth wash used frequently. If the patient is in a ward, the bed should be screened, so that he will not infect his neighbors when coughing. As few people as possible should come in contact with the patient, in order to prevent the making of carriers. The nurse must guard against becoming a carrier herself by disinfecting her hands in the same way as in other infectious diseases, and by avoiding droplet infection when the patient coughs.

In state hospitals and other institutions where there are chronic and infirm patients, there are probably always carriers, as cases of pneumonia keep cropping out among patients who have not been off the ward for months. More careful isolation and nursing of the actual pneumonia patients would reduce the number of cases of the disease in these institutions.

The Serum Treatment of Pneumonia. Types of Pneumococci.—There are different varieties, or *types*, as they are called, of pneumococci. Three types of pneumococci are recognized; these all look alike under the microscope and grow in the same way in the test-tube, but they can be distinguished by certain complicated laboratory tests, and they differ in the seriousness of the pneumonia which they produce. Types I and II each produce about one-third of all cases of pneumonia. Type III is less frequent, but it causes a very grave form of the disease. Pneumococci which do not belong to types I, II or III are grouped together and are spoken of as group IV. Group IV pneumococci are often found in the mouths of normal persons and cause a milder form of the disease than do any of the other types. Each type produces its own particular variety of antibodies which are effective only against that particular type of pneumococcus.

Many scientists have been working in recent years to prepare a curative serum for pneumonia. Up to the present time an efficient serum has been produced only against Type I. This is prepared by injecting a horse first with killed and then with living Type I pneumococci. The serum, after being taken from the horse, is given intravenously.

The serum is of value only in pneumonia caused by the Type I pneumococcus; it does not protect against the pneumonias caused by Types II, III, and IV. The *results* of the use of Type I serum have been most encouraging. With its use there has been a drop in the death-rate of Type I cases to about 8 per cent as contrasted with the usual death-rate of about 20 per cent in untreated cases. It must, however, like all sera, be given early in the disease, and injections must be repeated every eight or ten hours as long as seems advisable. The outcome of a case of pneumonia depends largely on whether the pneumococci get into the blood in large numbers. When this occurs recovery is very rare. The early use of serum may not entirely check the process in the lung, but it probably does help in limiting it to the lung and preventing the pneumococci from invading the blood. *When a patient* *has developed pneumonia, a specimen of sputum should be taken at once and examined to find out what type of pneumococci is present.* Treatment will be started at an earlier stage of the disease, and perhaps the serum may be given as a preventive measure to persons who are threatened with pneumonia. It is quite possible that effective sera against the other three types of pneumococci may soon be prepared, and also that the improvement of pneumococcus serum may pave the way for more efficient serum treatment in other diseases.

Pneumococcus Vaccine.—A vaccine made of killed pneumococci has been, and is still being tried for the prevention of pneumonia, but no definite statements as to its value can be made at present. The results are encouraging but not decisive. It was used in two Army camps in 1918 and may have had some effect in reducing the number of cases of pneumonia. Nothing has been done to promote its use among the general public, although some health departments have it for free distribution. The protection afforded by it is certainly not as great or as prolonged as in the case of antityphoid vaccine; nevertheless, it might be of considerable value for persons who are especially liable to develop pneumonia, as elderly people or invalids.

CHAPTER XIII

THE GRAM-NEGATIVE COCCI (NEISSERIA)

The Gonococcus (Neisseria gonorrheæ).—This organism was discovered in 1879 by a German physician, Neisser, hence its name *Neisseria.* It has a characteristic appearance under the microscope, the cocci being shaped like beans, and always occurring in pairs. It is, therefore, a diplococcus. It is Gram-negative. (See Plate I; Fig. 4.)

The gonococcus is a very delicate organism and difficult to grow in the laboratory, requiring serum or ascitic or hydrocele fluid for its growth. It has little resistance to heat, light, drying, or disinfectants, and dies quickly outside the body. When moist and protected from light, it may live in gonorrheal pus on sheets or clothing for as long as eighteen to twenty-four hours. It is most easily killed by chemicals containing silver, so these are used for its destruction in the form of silver nitrate, argyrol, or protargol.

The *diagnosis* is made in the acute stages of a gonococcus infection by finding the cocci under the microscope in stained specimens of the pus. They are characteristically enclosed within the leucocytes. (See Fig. 27.) In the chronic stages gonococci are very scarce, and more complicated laboratory procedures may be required to make the diagnosis.

Gonorrhea is an infection of the urethra and reproductive organs in both men and women, caused by the gonococcus. It begins as an acute inflammation which later becomes chronic. A great deal of pus is formed in the early stages, and may actually drip, unless absorbed by clothing or bandages. It is one of the most frequent of all the serious infectious diseases. In 1925 there were nearly 200,000 cases reported in the United States, and there were probably as many more cases not reported. It is transmitted in the great majority of cases by sexual intercourse, although gonococcus infections of other parts of the body and infections of children are acquired in other ways, which will be described later.

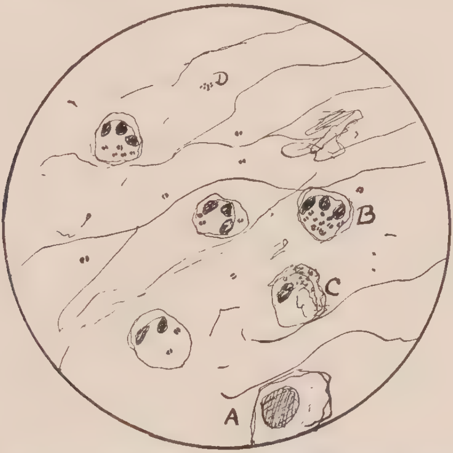

FIG. 27.—Stained smear of pus from a case of gonorrhea. A, Tissue (epithelial) cell; B, leucocyte filled with gonococci; C, leucocyte partly destroyed; D, other bacteria (probably staphylococci) often seen in such smears.

Gonococcus infection is almost never fatal, but it is exceedingly difficult to cure. If often starts up again after long treatment, when the patient believes he has been cured. Under such conditions a husband may infect his wife soon after marriage. It is never possible to say that a gonorrheal patient has really been cured.

In the female, the gonococcus causes an inflammation of the vagina, uterus, fallopian tubes, and ovaries. This condition is quite common and makes necessary many gynecological operations. In most gynecological clinics it is the custom to examine the uterine secretion of every patient for the gonococcus. Gonorrhea is one of the most frequent causes of childless marriages because it destroys parts of the female genital organs, (fallopian tubes).

Gonococcus Vaginitis. This is a fairly common disease in little girls. The infection of children in families in which there is an adult case of gonorrhea is more frequent than is ordinarily supposed. Infection comes about by sleeping in the same bed or by the common use of washcloths, towels, bath-tubs and toilets. The disease may spread in epidemic form in hospital wards, schools, and children's homes. It is exceedingly difficult either to cure the condition in the individual child, or to prevent its transmission to other children. It is the custom in all well-managed hospitals to delay the admission of little girls to the general children's ward until vaginal smears have been stained and examined with the microscope, and found "negative for gonococci." If the disease has once broken out in an institution, only the most rigid precautions in the handling and treatment of the cases will prevent its spread.

In the male, the gonococcus causes inflammation of the urethra especially. This may spread to adjacent portions of the genito-urinary system. The seminal vesicles, prostate and bladder may be affected. The urethra may become so scarred that urine cannot pass. This condition is commonly called stricture and requires surgical treatment.

Gonococcus Ophthalmia.—Inflammation of the eye, or ophthalmia, caused by the gonococcus is one of the most serious infections that can occur in that organ. The disease occurs both in adults and in newborn babies. A patient with gonorrhea may infect his eyes by means of his hands. Many doctors, nurses and medical students have lost an eye through infection from patients.

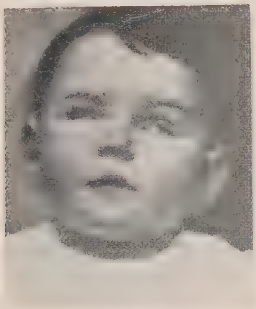

Fig. 28.—The end result of ophthalmia neonatorum (due to the gonococcus). The person in attendance at birth failed to instill silver nitrate solution into this child's eyes. The mother had had gonorrhea. The child will probably spend the rest of its life in an asylum for the blind (Courtesy Boston Nursery for Blind Babies).

If a woman who has gonorrhea gives birth to a child, the baby's eyes may become infected during the process of birth, and unless the condition is treated promptly and vigorously the child's sight may be destroyed within a few days. The disease, in newborn babies is called *ophthalmia neonatorum* (newborn). (See Fig. 28.) It has been estimated that the gonoccus causes about 10 per cent of all cases of blindness, and that there are in the United States over 10,000 persons blind for this reason. From 25 to 30 per cent of all children in schools for the blind in this country owe their affliction to gonorrhea.

Not all inflammations of the eyes of newborn babies are due to the gonococcus, but those caused by other germs are mild and do not have serious results. Some are caused by carelessness in washing the eyes, and are due to the Staphylococcus aureus, or other organisms, but it is impossible to distinguish the various kinds without examining the pus from the eyes under the microscope.

The number of cases of blindness due to the gonococcus is diminishing in civilized countries because of the general practice of putting a drop of a silver preparation into each eye immediately after birth. If done properly, this is an almost sure prevention of gonococcus ophthalmia. In the Sloane Maternity Hospital in New York City there were 4660 births during a period of six years in which this method was carried out, without a single case of ophthalmia neonatorum.

In most states the use of a silver preparation in the eyes at birth is required by law, and also the reporting to the health department within twenty-four hours of any inflammation of the eyes of a newborn baby. Outfits for treating the eyes at birth are furnished free by most health departments. The prevention of ophthalmia has a close relation to the midwife question, as it is most often the dirty or ignorant midwife who neglects the treatment of the eyes.

The Prevention of Gonorrhea.—See under Section III, "The Prevention of Venereal Disease."

The Meningococcus. (*Neisseria intracellularis.*) This organism exactly resembles the gonococcus in staining, morphology, cultural requirements and fragility. It ferments certain substances not fermented by the gonococcus. It causes an inflammation of the coverings (meninges) of the brain and spinal cord. The disease is called cerebrospinal meningitis or cerebrospinal fever, or "spotted fever."

Meningococcus meningitis occurs usually in small epidemics, and is therefore called *epidemic meningitis.* This form of meningitis should be differentiated from other types of meningitis which may be caused by streptococci, pneumococci, and other bacteria, but *never occur as epidemics.* Children are most often affected. The disease is spread chiefly by *carriers.* It is not highly communicable. The connection between cases is usually difficult to trace, as is true of all infections spread by carriers. Persons directly associated with the patient rarely contract the disease, although they often become carriers. Only a small proportion of carriers develop the disease. The meningococcus is passed along from person to person until a susceptible individual is reached, and he develops meningitis. *The meningococcus enters the body through the nasopharynx* (*Fig.* 29) *and probably reaches the meninges through the blood.* The disease is probably therefore, in its early stages, a *septicemia.* Meningococci are found quite constantly in the secretions of the nose and mouth during the first days of the disease, hence *droplet infection* is the most important and common mode of transmission of the disease.

Antimeningococcus Serum.—*An efficient curative serum for epidemic meningitis has been prepared by the injection of horses with cultures of different varieties of meningococci. The serum is injected directly into the spinal canal of the patient by means of lumbar puncture,* after allowing some cerebrospinal fluid to run off. An average dose of serum for an adult is 30 cc. The treatment is repeated daily for three or four days, and longer if necessary. Serum is also given intravenously to kill the meningococci in the blood.

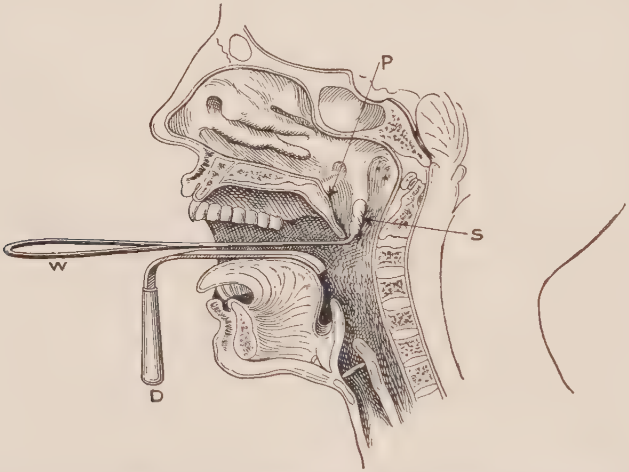

FIG. 29.—Illustrating the method of taking material from the naso-pharynx by means of a special swab: W, Wire holder of swab (S); P, soft palate; D, tongue depressor.

The *death-rate* from meningococcus meningitis before 1906, when the serum came into use, varied between 60 and 80 per cent. The effects of the treatment depend, as with every other curative serum, on the stage of the disease at which it is begun. The results obtained in large series of cases treated in various countries are given in the following table:

Treatment Begun	Death-rate
Before third day	7–18 per cent.
From fourth to seventh day	11–27 per cent.
After seventh day	24–50 per cent.

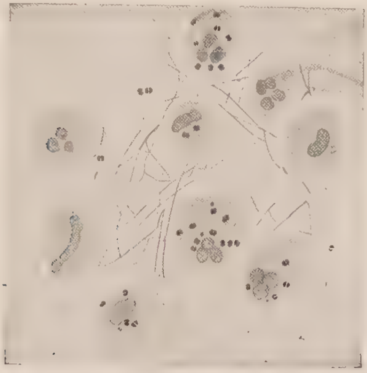

Fig. 30.—Meningococci in the leuocytes in the cerebrospinal fluid in a case of epidemic meningitis. The cocci occur in pairs and look like gonococci (see Plate I; Fig. 4). The network between the cells is fibrin (Jordan).

In any case in which there is a suspicion of meningitis it is of extreme importance to make a lumbar puncture immediately and examine the cerebrospinal fluid bacteriologically. The diagnosis is made usually from a Gram stained smear of *the sediment* (see Fig. 30). Cultures may also be made.

CHAPTER XIV

THE PATHOGENIC BACILLI

As in the case of the micrococci, there are both Gram-positive and Gram-negative bacilli. Some types of bacilli are motile. Some are able to form spores. (None of the *cocci* studied in this book either bear spores or are motile.) In addition, there is a large group of bacilli which are so constituted that they can grow only when air is excluded. Such bacteria are said to be *strictly anaërobic* (anaërobic-living without air). Bacteria which *cannot* grow when air is excluded are called *strict aërobes.* Bacteria which have the faculty of growing in either the presence or absence of air are called *facultative.*

The various bacilli which we shall discuss in this book may be tabulated as follows:

GRAM-NEGATIVE

(No Spore Bearers)

Group 1	B.* coli (inflammation of bladder—cystitis)
	B. typhosus (typhoid fever)
	B. paratyphosus (types A and B) (paratyphoid fever)
	B. dysenteriæ (bacillary dysentery)
Group 2	B. influenzæ (influenza—doubtful)
	B. pertussis (whooping cough)
	B. bronchisepticus (disease resembling whooping cough)

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* The letter *B.* is used as an abbreviation of the word "bacillus."

GRAM-POSITIVE

Aërobic
  B. tuberculosis (tuberculosis)
  B. anthracis (anthrax)
  B. diphtheriæ (diphtheria)
Anaërobic (all spore bearers)
  B.* welchii (gas gangrene)
  B. tetani (tetanus or lockjaw)
  B. botulinum (food poisoning)

The Gram-negative Bacilli.—As indicated above, the organisms to be considered under this heading may be divided into two groups; first, those which are related to the intestine and its diseases, and second, those related to the respiratory tract. With the first group we shall also discuss briefly the organism which causes Asiatic cholera. This is a spirillum, but in many respects is so much like the bacilli of this group that it may as well be considered at the same time.

The Intestinal Gram-negative Bacilli. The organisms of this group have many characteristics in common. In addition to being Gram-negative bacilli which look alike under the microscope, they all grow well on ordinary laboratory media at temperatures ranging from 20° to 39° C. Since they do not form spores all are easily killed by a few minutes boiling, by pasteurization, and by good disinfectants as ordinarily used. All are motile except B. dysenteriæ. They differ in their action on various carbohydrates. Some change the carbohydrates into acid and gas, some do not. These differences are shown clearly in Table I, and are used to identify the members of the group.

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* *Clostridium* is the proper term to use for these anaërobic bacteria, but because of common usage the name Bacillus will be continued in this edition. For the same reason, Bacillus instead of mycobacterium is used for the organism of tuberculosis, and Bacillus instead of Corynebacterium is used for the organism of diphtheria.

All of these organisms are discharged from the body in the feces, and gain entrance to it through the mouth. The diseases they cause are all, therefore, transmitted in the same way, *i.e.*, by anything polluted with the fecal material.

The most important member of the group is B. typhosus, the cause of typhoid fever.

TABLE 1.—CHARACTERISTICS COMMONLY USED TO DISTINGUISH BETWEEN BACILLI OF THE GRAM-NEGATIVE INTESTINAL GROUP

Organism	Action on common carbohydrates (sugars)			Motility
	Lactose (milk sugar)	Dextrose (glucose)	Saccharose (cane sugar)	
B. typhosus	No change	Acid only	No change	Active
B. paratyphosus	No change	Acid and gas	No change	Active
B. dysenteriæ	No change	Acid only	No change	None
B. coli*	Acid and gas	Acid and gas	Acid and gas	Active

* Some strains of B. coli do not ferment saccharose.

The Typhoid Bacillus and Typhoid Fever.—The typhoid bacillus was discovered by a German physician (Eberth) in 1880, in the spleens of typhoid patients who had come to autopsy. It had been known for some time before this, however, that typhoid fever was an infectious disease. Although the bacillus develops chiefly in the human body, it is also found in the outside world in water polluted by sewage from typhoid cases, and it can grow very readily in milk. It is quite hardy outside the body and can survive for some time in water, sewage, oysters, etc. Observations have shown that it may live for seven days in water, twelve days in sewage, four months in butter, and thirty-nine days in ice cream. It is not killed by freezing.

The bacilli enter the body through the mouth, by means of infected food or drink, such as water or milk containing the germs, food that has been handled by persons with the bacilli on their hands, raw vegetables for which sewage has been used as a fertilizer, or shellfish which have grown in water polluted with sewage. They seem to pass through the stomach uninjured, and multiply in the intestine.

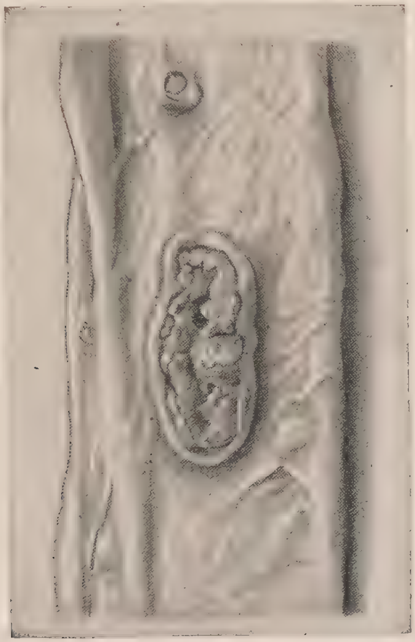


Fig. 31.—Typhoid ulcers of the intestine as they appear in the second week of the disease. The intestine has been opened and we are looking at the inside. There may be serious hemorrhage from these ulcers. If the ulcer breaks through to the outside of the intestine, peritonitis will occur (MacCallum, Text-book of Pathology).

The bacilli appear in the circulating blood only in the first week of the disease. Typhoid is really, therefore, at first a septicemia, although later on ulcers of the small intestine are always present. (See Fig. 31.)

Typhoid bacilli begin to appear in the stools in the latter part of the disease and by the second week are present in enormous numbers. Billions may be passed in a single movement. The bacilli usually decrease during convalescence and finally die out. In about 11 per cent. of patients, however, they continue for eight to ten weeks, and in 2 to 4 per cent they persist indefinitely. The first group are *convalescent carriers*, and the second group *permanent carriers*.

The bacilli appear in the urine about the fifteenth day of the disease, often in great numbers. They may continue for weeks, months, and in rare cases for years. There are thus urinary as well as fecal typhoid carriers.

How Typhoid Is Spread.—The source of infection is the feces and urine of the typhoid patient. Each case comes from a previous case or from a carrier; that is, the bacilli from the excretions of the first case are in some way, often hard to trace, taken into the mouth of the second patient. This is a very disagreeable fact, but it is necessary to face it.

The ways in which the disease is spread are by actual cases, carriers, flies, water, and milk and other foods.

1. *Contact with Patient.* Typhoid is frequently spread by direct contact with the patient. This is the way in which nurses and members of the patient's family contract the disease; that is, they soil their hands while caring for the patient and neglect to wash them before going to meals, or they put their fingers in

their mouths. If a nurse catches typhoid from a patient, it is at least strong evidence that she has been careless. Other examples of direct transfer of the bacilli come readily to mind: a convalescent fingers a piece of food and passes it on; a laundress handles clothing soiled with typhoid excretions; the mother of the family may have to nurse the patient and prepare the family meals, going to and fro between the sick room and the kitchen.

In a study of the sources of typhoid in Massachusetts in 1918–1919 it was found that 13 per cent of all cases were due to direct contact with a typhoid patient, and that 1 in every 38 persons exposed in the family contracted the disease. These cases are preventable. The greatest danger is in the early stages of the disease before the diagnosis has been made and disinfection of the excretions begun. Some cases of typhoid are very mild, showing nothing more than a little fever with intestinal disturbance and diarrhea. Unless typhoid is suspected, no precautions are taken, and there is ample opportunity for spread of the infection. We have already seen how large is the part of mild and unusual cases in spreading scarlet fever and diphtheria, and they are important also in typhoid.

2. *Carriers* are extremely important in the spread of typhoid. Carriers have been reported who had had the disease as long as 64 years before they were discovered. The source of the bacilli in the feces is probably the gall-bladder, in which the organisms continue to live and multiply as comfortably as in a culture-tube in the incubator. Thence they are carried to the intestine with the bile. There is no certain way known at present to prevent a patient from developing into a carrier. There is also no successful method of curing

carriers, although various kinds of treatment have been tried.

Carriers are a continual source of danger if they have anything to do with the preparation of food or milk, and many epidemics have been traced to them. The history of such an epidemic, which occurred in a California town a few years ago, illustrates what may happen. A large number of typhoid cases broke out in a certain town within a few days of one another. It was found that all the patients had attended a certain supper about three weeks previously, and the one dish of which they had all eaten was creamed spaghetti. The woman who had contributed this to the supper had had typhoid many years before, and examination of her feces by the State Board of Health proved that she was still a carrier. This woman had been a boarding house keeper for many years and a number of cases of typhoid had developed among her boarders. She had contaminated the spaghetti in this particular case with typhoid bacilli from her fingers, while preparing it. It was baked in a large pan. It has now been shown by experiment that when large dishes of food or big pieces of meat are cooked for only 30 to 40 minutes in the oven, the heat often does not have time to penetrate to the center. The center may become warm, but not really hot enough to kill bacteria. So, in this case, the organisms in the center of the mass had not been killed by the heat, but on the contrary had multiplied as if they had been in a culture-tube in the incubator. There were 93 cases of typhoid altogether, including the persons infected from the carrier and those which developed from contact with the first cases. About 10 people died.

The number of carriers in a community depends on the number of typhoid cases. Where typhoid is frequent, carriers are numerous. The vast majority of typhoid carriers are never discovered. Only those are known who have been proved to be the cause of other cases of the disease. When the source of infection of typhoid cases is traced, as all health departments try to do nowadays, the part played by carriers is found to be increasingly important. Probably more than one-third of all cases are due to them. Many of the cases in which the source of the infection cannot be traced are doubtless due to undiscovered carriers. The carrier is the most important single factor in the spread of typhoid, and the hardest to control.

3. *Flies* can act as distributors of typhoid bacilli. Typhoid cases are most numerous in the fly season. These insects contaminate their feet with the typhoid feces, then crawl over food, depositing the bacilli on it, or drop into milk and inoculate it with typhoid bacilli as though it were a culture tube. In screened and sewered communities flies are probably not an important means of spreading the disease, but in the country, where there are unsanitary privies and no screens, flies may be an important factor. The same is true in military camps and unscreened wards for untidy mental patients.

4. *Milk* and other foods contaminated by actual cases or by carriers or flies account both for many scattered cases and for numerous epidemics. As has been said, the typhoid bacillus grows rapidly in milk without changing its appearance or taste. The germs may get into the milk from the hands of the dairyman or milkman, in case he or any of his family have

typhoid, or from washing the cans or bottles in infected water, or from using milk bottles in the typhoid patient's room. The most extensive typhoid epidemic of this century occured in 1927 in Montreal and was believed to be due to an infected milk supply. In this epidemic there were 4755 cases of typhoid fever and 453 deaths. It seems that for some reason the sanitary regulations failed to function properly for a time and the result was this appalling loss of life and money. Too much stress cannot be laid upon the proper control of public milk supplies. Had the milk been properly pasteurized just before delivery or consumption, there would have been no epidemic at all.

Epidemics have also been traced to *ice cream* made from milk containing typhoid bacilli, proving that some of the bacilli remained alive even after the milk which contained them had been frozen.

5. *Water* polluted with sewage used to be the most frequent source of typhoid. Within the last twenty years, however, practically all American cities have provided themselves with good water supplies, and the greater part of the typhoid in cities is now due to other causes than water. In the country districts and in villages, on the other hand, polluted water still accounts for many scattered cases of typhoid. Wells and privies are situated near together and the feces are washed by rains or tracked by animals over the ground and into an open well. The bacilli may also be carried through the soil, with underground seepage and streams, into the well (see Fig. 32).

Epidemics of water-borne typhoid, however, still occur. The water may be contaminated in various ways. There may be some trouble or carelessness at the purification plant, so that the water is distributed without disinfection. A typhoid patient living near a stream which forms part of a city water supply may be responsible for many cases in a community a long distance away. A celebrated epidemic in a Pennsylvania town was caused in this manner. A man living beside a mountain stream, which supplied a town a number of miles away, had typhoid in November. His excretions were thrown, without disinfection, into the earth closet. In the spring, after a thaw, an epidemic of typhoid suddenly broke out in the town below and was traced to the water supply, and finally back to the single typhoid patient on the mountain. There were 1104 cases in the epidemic and 114 deaths. The bacilli in this case remained alive over the winter and were washed into the stream during the spring thaw.

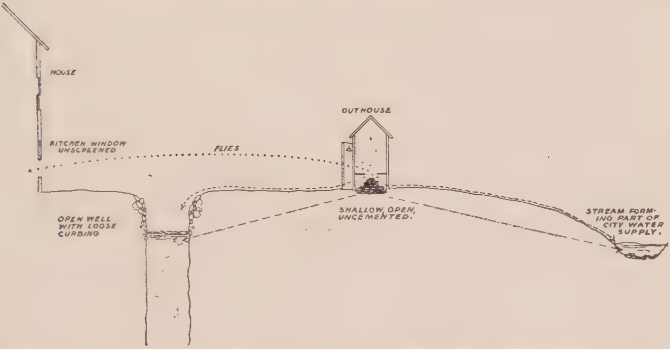

HOUSE
KITCHEN WINDOW UNSCREENED
FLIES
OUTHOUSE
OPEN WELL WITH LOOSE CURBING
SHALLOW, OPEN, UNCEMENTED.
STREAM FORMING PART OF CITY WATER SUPPLY.

FIG. 32.—Diagram showing how an unsanitary outhouse can be a source of contamination for a city water-supply, a household well, and a kitchen.

Typhoid bacilli do not multiply in water, as they do in milk, but they can remain alive in it for some time.

Diagnosis.—The diagnosis of typhoid is made in the *early stages* of the disease by means of a *blood culture.* The diagnosis may be made in this way only during the first week, since, after 7 or 8 days, the bacilli disappear from the blood. Ox bile obtained from the slaughter-house is used in the culture, as it is favorable for the growth of typhoid bacilli and unfavorable for the other germs. (Compare with the growth of typhoid bacilli in the gall-bladder of carriers.) Later in the disease the bacilli may be cultivated from the stools. The culture is purified by spreading a drop of feces on plates of agar, incubating 24 hours and then selecting a well isolated colony. This colony is cultivated in broth and examined microscopically and by means of its fermentations. (See Table I on page 142.)

Carriers are detected by finding the bacilli in cultures from their feces.

Widal Reaction.—The blood of a typhoid patient gives a test called the "Widal reaction." The test is named after the French physician Widal, who discovered it. The reaction depends on the fact that during the course of the disease substances appear in the blood which have the power of gathering the bacilli into clumps or masses. A drop of a broth culture of known typhoid bacilli is mixed with a drop of the patient's diluted blood serum and examined under the microscope. The bacilli are at first seen swimming around actively, each one separate, but if the test is *positive,* within fifteen or twenty minutes their movement stops and they gather into clumps (see Fig. 33). This is called agglutination and is due to antibodies in the patient's blood called *agglutinins* (p. 74). The agglutinins do not appear in the blood until the second week of the disease or later. The reaction, therefore, cannot be used for the early diagnosis of typhoid, but it is useful in the later stages, and also in determining whether a patient has had typhoid at some time in the past.

The Widal reaction is also positive in *carriers* and *persons who have been injected* with dead typhoid bacilli (typhoid vaccine) for the prevention of the disease, as will be described later. A "positive Widal reaction" means, therefore, that the person either *has typhoid at the present time*, or *has had it*, or *has been immunized against it.* The reaction is very reliable and is much used.

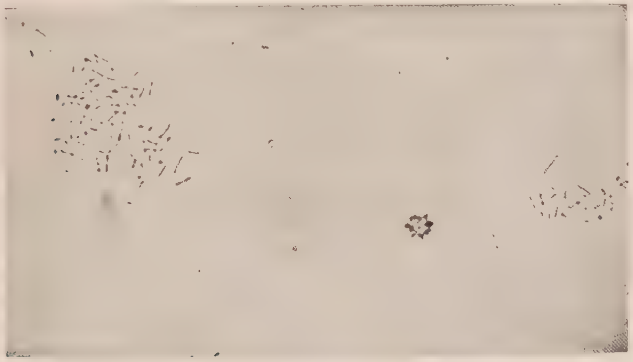


Fig. 33.—A positive Widal reaction as seen under the microscope. Most of the typhoid bacilli have collected in clumps. A few are still free (Wright and Brown).

Agglutination Test.—A similar test is used in identifying bacilli isolated from the stool. In this test a broth culture of *unknown bacteria* isolated from the patient is mixed with a little *known typhoid serum* to see if the bacteria in the culture are agglutinated by the serum. This is called an *agglutination test.* It is just the reverse of the Widal test. Both tests depend on the presence of the proper antibody in the serum. If the bacteria are agglutinated, they must be typhoid bacilli. If they are not agglutinated they are some other organism. Known typhoid serum is kept in the laboratory for testing bacteria from various sources.

Paratyphoid Bacilli. Paratyphoid Fever.—Paratyphoid bacilli resemble typhoid bacilli in general characteristics (*para* means like) and cause fevers similar to typhoid but milder. They cause milder types of diarrhea and are very often the cause of *food infection* because there are animal carriers (rats and mice) which distribute the germs in their feces. Cows and steers are sometimes infected with paratyphoid-like bacilli and if the flesh is eaten improperly cooked, meat infection is apt to occur. This may show itself as diarrheas varying in severity from very mild to fatal. The paratyphoid bacilli are spread chiefly by carriers and food. They are less hardy outside the body than B. typhosus.

CHAPTER XV

TYPHOID FEVER (*Continued*). DYSENTERY

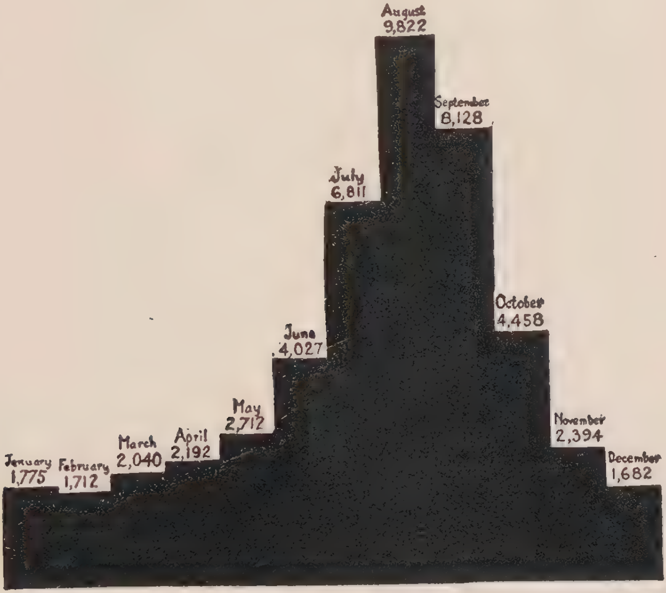
Antityphoid and Paratyphoid Inoculation.—It is possible to produce immunity to typhoid and paratyphoid fever by giving injections of dead typhoid or paratyphoid bacilli. The treatment consists in giving three doses of vaccine one week apart, the first of 500,000,000, the second and third of 1,000,000,000 bacilli. The injections are usually followed within twenty-four hours by considerable swelling and soreness of the arm. There are sometimes general symptoms—headache, nausea, and a rise in temperature—but these are not serious and they pass off in twenty-four hours. The most suitable time for giving the inoculations is late in the afternoon. The person should keep quiet for the rest of the day and should not undertake very hard work on the following day. Saturday afternoon is a good time to give the injections.

The vaccine usually given consists of a mixture of typhoid bacilli and the two varieties of *paratyphoid bacilli*, called A and B. It is possible to protect against both typhoid and paratyphoid at the same time with scarcely any increase in the reaction.

Results of Antityphoid Immunization.—The reduction of typhoid fever where typhoid vaccine has been used on a large scale, as it is in the army, has been truly marvelous. *It is one of the great successes of preventive medicine.* Antityphoid immunization was made compulsory in the United States Army in 1911, and in the World War it thoroughly justified itself. In the former wars typhoid had been responsible for more sickness and deaths than all the wounds of battle. In the Spanish-American War (1898–99) one in every seven men developed typhoid, and one in every seventy-one died from it. During the World War, in which our troops were often exposed to very unsanitary conditions, there were only 156 deaths among the 4,000,000 United States soldiers due to typhoid or paratyphoid. If there had been as high a death-rate from typhoid as in the Spanish War, there would have been 68,164 deaths!

Duration of Immunity.—Following the injections of vaccine the cells of the body produce antibodies which protect against typhoid bacilli. *This simple treatment gives a high degree of protection against typhoid fever for a considerable time.* It is not possible to say just how long the immunity lasts. It begins to fail after a time, but some degree of protection remains for a number of years. In the army the men are reinoculated every three years. The protection depends also on the number of doses; less than three are insufficient to immunize. Human beings, like animals, differ in their ability to manufacture antibodies in response to the stimulation of the vaccine. Some produce them abundantly, others only in small amounts.

Inoculation is not an absolute protection against typhoid at any time, for a recently inoculated person may develop the disease if he receives an immense dose of virulent bacilli. The treatment will, however, protect against the moderate doses which one is likely to get in ordinary chance infection. An inoculated person must not relax any precautions that he would otherwise take. An immunized nurse should be as scrupulously careful about washing her hands and taking all other measures to protect herself as if she were not inoculated.



ONE-FIFTH OF ALL THE DEATHS OF CHILDREN UNDER 2 YEARS OF AGE ARE CAUSED BY DIGESTIVE DISORDERS WHICH ARE LARGELY PREVENTABLE

CHILDREN'S BUREAU, U.S. DEPARTMENT OF LABOR.

FIG. 34.—Deaths of children under two years of age from diarrhea and enteritis in the United States in 1918. Note the summer peak.

Bacillary Dysentery.—This is an infectious disease caused by the dysentery bacillus. The disease appears in two forms: first, as it is seen in adults, and second, as a severe form of summer diarrhea in babies (see Fig. 34).

Dysentery Bacilli.—There are several varieties of dysentery bacilli. The first one of the group was discovered by a Japanese physician, Shiga, in 1898. A second type was discovered by an American physician, Flexner, in 1906; and there are now a number of other types known. Dysentery bacilli grow well in the laboratory and are easily killed by heat and disinfectants. They remain alive outside the body for only a short time as compared with the typhoid bacillus, on food, cloth, or in the soil. They grow in milk without changing its appearance or taste. They may be differentiated from other bacilli in the group by the characters shown in the table on page 142.

The bacilli cause ulcers of the large intestine and the most intense and painful diarrhea. The feces contain blood, mucus, and pus. The organisms do not occur in the blood, like the typhoid bacillus, but are limited to the large intestine. *They form a powerful poison, which causes the prostration and loss of weight associated with the disease.* The bacilli are cast off in large numbers in the bowel movements, and may persist for months in convalescents.

Methods of Spread.—The disease is spread in much the same manner as typhoid fever, that is, by fingers, flies, milk, foods, and by any articles or hands which have been in contact with the bowel movements of a previous case. In many instances the severe form of the infection in infants is contracted from a grown person or an older child in the family, who is suffering merely from a mild diarrhea. The same bacillus which causes only a diarrhea in an adult may give rise to a fatal dysentery in a baby. Water borne epidemics of dysentery are rare.

Inoculation against dysentery seems to have little value although the Polish Government recommends it and believes it to have done a great deal of good in preventing dysentery.

The serum treatment of dysentery seems to be fairly successful. A serum is used which is active against the several types of dysentery bacillus.

Bacillus Coli.—This is a harmless organism, usually, and lives normally in the intestine. It may, however, cause inflammations of the bladder called *cystitis.* It is, in general, a hardier organism than B. typhosus. Its characters are shown in the table on page 142. It very much resembles B. typhosus in growth and appearance.

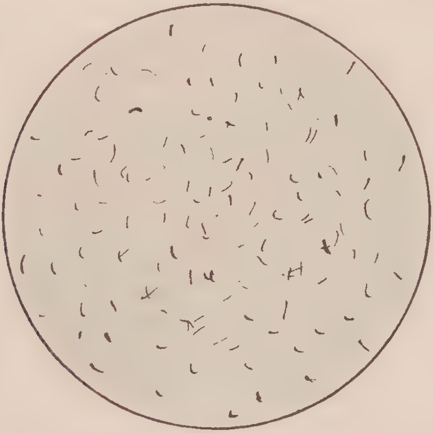


FIG 35.—Stained smear of curved bacteria (spirilla).

The Cholera Spirillum and Asiatic Cholera.—The cholera spirillum is very much like the typhoid bacillus in many respects. It is, however, curved spirally (see Fig. 35). It is Gram-negative, motile and nonspore bearing, and easily killed by boiling, pasteurization and good disinfectants. It is spread about in exactly the same manner as the typhoid bacilli. It causes Asiatic cholera, the chief symptoms of which are intense diarrhea, prostration, emaciation, and usually death, unless treatment be started in time.

Vaccination is said to be a good preventive measure. There is little or no cholera in the United States although it is common in China, India and other oriental countries.

CHAPTER XVI

THE GRAM-NEGATIVE BACILLI ASSOCIATED WITH THE RESPIRATORY TRACT

Bacillus influenzæ is one of the smallest bacilli (see Plate I; Fig. 3). It is very particular in its growth requirements. It must have the red coloring matter of the blood (hemoglobin) or certain unknown substances which can be extracted from potatoes or yeast. It grows only at body temperature. It is not motile and extremely delicate, and will die soon outside the body. It is, of course, easily killed by heat and disinfectants.

It is found in the nose and throats of many normal people and is transmitted in droplets in sneezing and coughing. It is found in many inflammatory conditions of the respiratory tract, such as bronchopneumonia, and has been found in pure culture in the blood of patients dying of other diseases. It may sometimes cause meningitis.

Bacillus Pertussis and Whooping Cough.—Whooping cough is caused by a small bacillus called B. pertussis, discovered in 1906, by two Belgian workers, Bordet and Gengou. It produces an inflammation of the trachea and bronchi, and consequently is found in the sputum, saliva, and nasal discharge. The bacillus grows slowly and with difficulty outside the body. It has the same fastidiousness about its media that the influenza bacillus has. It, also, is Gram-negative and non-motile, and forms no spores. It is transferred directly from person to person by droplet infection during coughing, and by articles soiled with nose and mouth secretions. A spray of sputum and saliva may be thrown out to a distance of 4 or 5 feet during the violent attacks of coughing.

Whooping cough begins with the symptoms of an ordinary cold. It is most infectious during the first few days of the actual disease, when the bacilli are present in the sputum in enormous numbers. The bacilli may linger for some time after convalescence, so that by many it is thought best to keep a child isolated for several weeks after the cough has stopped.

Whooping cough, like measles, is a more serious disease than is generally realized on account of the other infections which complicate or follow it, the most important of which are bronchitis, pneumonia, and tuberculosis. Whooping cough is really responsible for many fatal cases of bronchitis and pneumonia in young children. It caused about 7000 deaths in the United States in 1925. Ninety-seven per cent of the fatal cases occur under five years, and 50 per cent under one year.

Whooping Cough Vaccine.—In the last few years a vaccine made of killed whooping cough bacilli has been used to some extent for the prevention of the disease. There is some difference of opinion as to its value, but most of the reports are favorable. It seems to have considerable value in preventing the disease. Epidemics in institutions have been stopped by immunizing all the children as soon as the first case appeared. The vaccine is of less value for the cure of the disease than for its prevention. Nevertheless, in some cases it does reduce the severity of the fits of coughing and shorten the course of the disease. The treatment is entirely harmless, and it seems probable that in the future it will be used on a larger scale for both prevention and treatment. The vaccine is furnished free by some health departments.

Bacillus Bronchisepticus.—This is a very small Gram-negative bacillus causing distemper in dogs and symptoms in children very much like whooping cough. Its relation to human infection was discovered by Brown at Johns Hopkins, in 1926. It is transmitted in the same way as B. pertussis. Rabbits, dogs and other pets may act as *carriers*. It is differentiated from B. pertussis and B. influenzæ in being motile and able to grow on ordinary media. It seems very probable that many cases thought to be genuine whooping cough are in reality due to B. bronchisepticus. It is also possible that the difference of opinion regarding the value of vaccine made from the pertussis bacillus may be due to the fact that many of the diseases treated with B. pertussis vaccine were really being caused by B. bronchisepticus, a different germ.

Bacillus Ducreyii.—The bacillus of Ducrey is very much like the influenza bacillus and B. pertussis and is therefore included here although it causes no infection of the respiratory tract, but a venereal disease called *chancroid* or *soft chancre*. The disease is transmitted by sexual intercourse and by the use of articles contaminated with the pus and serum from lesions. It spreads over the surfaces and erodes the tissues of the genitalia. The disease yields quite readily, as a rule, to good vigorous disinfection of the affected parts and to personal hygiene.

CHAPTER XVII

THE GRAM-POSITIVE BACILLI

Regarding the Gram-positive bacilli which are to be discussed in this book, it has already been pointed out (Chap. XIV) that the spore bearers are, with one exception, strict anaerobes. The exception is the germ causing anthrax.

Anthrax ("Malignant Pustule" or "Woolsorter's Disease").—This is a disease which causes considerable losses among cattle and sheep each year, especially in European countries. In 1925 there were 52 deaths in six states, due to anthrax. It is communicable to man and is a dangerous infection. It is caused by a Gram-positive, non-motile, strictly aërobic bacillus, called *Bacillus anthracis.* When seen under the microscope it is rather large and has square-cut ends (see Plate II, Fig. 4). It grows well on ordinary media at room and body temperatures. The spores are among the most resistant known. Boiling for hours is sometimes necessary to kill them. Autoclaving should be prolonged for one hour or more at higher pressures. Ordinary disinfectants do not kill them in the time and concentration commonly used.

Man contracts the disease by getting the spores from the hides and wool of cattle and sheep into cuts or scratches in his skin. A pustule soon forms which is teeming with the bacilli. It enlarges rapidly, becomes red and angry looking and is later covered with a black crust. The bacilli soon invade the blood stream and multiply there rapidly and extensively and the patients very frequently die. Anthrax presents a good example of *virulence due to aggressiveness* alone, for the bacillus is not known to form any toxin.

In nursing a case of anthrax, all dressings should be burned immediately. The greatest care must be exercised not to allow any of the discharges from sores to get on the nurse's hands or on any articles to be handled by anyone. In the last stages of the disease the bacilli may also be discharged in the urine, feces and oral and nasal secretions and care must be exercised in handling these also.

Anthrax is not a common disease in man.

There is a fairly good *therapeutic serum* for the treatment of anthrax.

Gas Gangrene. Wound Infection. B. Welchii, Etc. *The spores of all of the anaërobic bacilli mentioned in this book are found in the soil*, especially those of the gas gangrene group and the tetanus bacillus. *The latter organisms themselves are common inhabitants of the intestinal tract of man and animals.* The tetanus bacillus is particularly common in horse manure. It is easy to see, therefore, that any street wound, or cut or abrasion received on the farm or elsewhere which becomes filled with manured soil, must contain the spores of the organisms of gas gangrene and tetanus.

Gas gangrene is a name applied to the condition which develops following the formation of a *deep, dirty* wound, such, for example, as a bullet or bombshell wound, or a dirty nail puncture which is not properly cleaned out and treated. The bacteria which are responsible for the condition have two chief properties. The first of these, and possessed particularly by *B. welchii*, is the *formation of large amounts of gas in the tissues about the wound.* B. welchii is commonly called the "gas bacillus." When its spores lodge in a deep wound, they there find ideal conditions for growth. It is warm, moist, there is dead tissue for food and, because the wound is deep, the air is excluded and strict anaërobes can grow. Gas is formed. The bubbles press on blood vessels and the tissue dies for want of blood and becomes gangrenous or putrid and swelled and distended with gas, because the bacilli soon invade the dead tissue. Thus the condition spreads and may destroy a whole limb in a comparatively short time.

Other bacteria associated with the "gas bacillus" (B. fallax, B. histolyticus, B. tertius and a number of others) have much less gas-forming power, but produce enzymes which dissolve tissues and so help the gangrenous process along. Gas gangrene is not, properly speaking, an infectious disease. It can be prevented by proper and prompt treatment of wounds. *Deep, dirty* wounds are to be carefully cleaned, opened as much as practicable, drained, irrigated and made to heal from the bottom up. Exposure of the depths of the wound to air, as far as possible, prevents the growth of the anaërobes. All dead tissue should be cut away.

Of the many bacteria causing gas gangrene, **B. welchii** is the most important. It is a short, thick bacillus with rounded ends (see Plate II; Fig. 5). The spore is formed near the center and appears like a hole in the bacillus unless stained by special spore stains. When cultivated in milk it produces much acid, which clots the milk. Gas is then formed and the clot is torn to shreds and the plug may be blown from the tube. Such a process is commonly called "stormy fermentation" of milk and is one of the most characteristic cultural appearances of the Welch bacillus.

The laboratory study of the anaërobic bacteria requires special apparatus which enables one to exclude air from the cultures. Broth and other cultures are often sealed with vaseline or paraffine to exclude air.

Serum treatment of B. welchii infections is quite successful. Such serum is often given a patient who is admitted to the accident ward with a wound which shows possibilities of gas gangrene. It is an *antitoxic serum*, since B. welchii secretes an exo-toxin. Welch antitoxic serum was used with good results during the World War. It was developed by Bull and Pritchett in 1918, at the Rockefeller Institute, New York City.

The Tetanus Bacillus and Tetanus Antitoxin.—Tetanus (lockjaw) is, fortunately, a rare disease. The bacillus, as we have mentioned above, is a spore former. The spore, situated at *the end* of the bacillus, gives the organism a "drumstick" appearance. (See Plate II; Fig. 6.) When protected from sunlight and other injurious influences the spores may remain alive and virulent for many years. One investigator produced tetanus in an animal with bacilli from a splinter of wood infected eleven years before.

When the bacilli grow in a wound they produce the deadly disease tetanus. If, however, they are taken into the intestinal tract they are entirely harmless. This is a striking illustration of the fact mentioned in Chapter V, that the pathway by which an organism enters the body is of great importance in determining whether or not disease will occur, and that the majority of bacilli can cause an infection only when they enter through their own particular route.

The tetanus bacillus causes the disease by means of a powerful exo-toxin which it produces. Tetanus toxin is one of the most deadly poisons known; the injection of 0.000,005 cc. of a broth culture of the bacillus (which contains the toxin) is sufficient to kill a mouse. The harmful action of tetanus toxin is due to its action on the *brain* and *spinal cord.* This action is shown by the convulsions to which death from the disease is due. The toxin reaches the brain and cord by traveling up the motor nerves in the vicinity of the wound. It is also distributed through the blood.

Tetanus Antitoxin.—This is obtained in the same way as diphtheria antitoxin; that is, by injecting horses with broth in which tetanus bacilli have grown, and which contains their poison or toxin. The *curative* value of this antitoxin is much less than that against diphtheria, but it has immense value in *preventing the development of the disease. It is, therefore, a general practice to give a prophylactic or immunizing dose of* 500 *to* 1500 *units to patients who have wounds in which tetanus bacilli are liable to develop.* During the World War there was a frightful amount of tetanus from trench fighting until every wounded man was given an immunizing injection as soon as he came under medical care. The result of this first-aid treatment was the complete elimination of tetanus as a cause of death among the wounded.

After the tetanus toxin has affected the nerve tissue the antitoxin cannot neutralize it; hence, the great importance of giving the antitoxin as soon after the injury as possible. The poor results obtained with antitoxin given after symptoms of the disease have developed are largely due to this fact. In severer cases the antitoxin is given both intravenously and intraspinally.

Tetanus is also prevented by the proper treatment of wounds. Every wound, however slight, should be thoroughly cleansed; it should be fully opened and every particle of foreign material removed. All *deep wounds* containing *dirt* should receive special attention.

Botulism (Food Poisoning). B. Botulinum.—The botulism bacillus resembles the Welch bacillus very much in appearance, in being a Gram-positive, spore-bearing anaërobe and in being found in the soil. It differs culturally in forming no gas, in being motile, and (probably) in not being able to grow in the human body. The latter statement raises the question:—How, then, does it produce disease?

The botulism bacillus can grow well in canned foods that are not too acid. Canned beans, meat, corn, or any such foods may support the growth of this organism. If spores of the organism are enclosed in the cans and not killed by the "processing" or autoclaving at the canning factory, they may germinate. The bacillus gives off an extremely powerful toxin, which, when swallowed, will nearly always prove fatal. The appearance, taste or odor of the food may give absolutely no hint of the presence of B. botulinum toxin.

It is easy to protect everyone against botulism, because the toxin is *destroyed and made harmless by a few minutes boiling.* For absolute safety therefore, *all canned foods should be held at boiling for a few minutes before eating.* As a matter of fact, however, there is little danger now-a-days from eating canned foods. The canners themselves take excellent precautions against botulism by cleanly preparation and thorough autoclaving of all canned goods. *Any cans which show bulging ends should be discarded, as well as any cans showing evidences of fermentation or acid or gas formation.*

There is an efficient *serum* which may be used for the *prevention* of botulism. Once the symptoms have started however the patient's chances of recovery are very slender.

CHAPTER XVIII

THE DIPHTHERIA BACILLUS AND DIPHTHERIA

Diphtheria starts as an acute inflammation of the throat caused by the diphtheria bacillus. When the bacillus grows on the tonsils and walls of the throat, it causes the usual form of diphtheria. It may grow also in the nose, producing nasal diphtheria, and in the larynx, causing what used to be known as "membranous croup," but what is now generally called *laryngeal diphtheria.* The bacillus forms a grayish-white covering or *membrane* where it grows, which is characteristic of the disease.

The diphtheria bacillus was discovered in 1883–84 by two German physicians, Klebs and Loeffler, and is sometimes spoken of as the "Klebs–Loeffler" bacillus. These bacilli have a characteristic appearance under the microscope, especially when stained with *methylene blue.* They are Gram-positive but the Gram stain is not often used to stain these organisms. When stained with methylene blue they are curved and have dots at the ends and often bars through the middle. After they are ten hours or more old they assume curious shapes resembling clubs, dumb-bells, and exclamation points. (See Fig. 36.) The bacilli grow well in the laboratory on certain media, so that it is usually possible to tell in twelve hours from the time a throat culture is started whether or not diphtheria bacilli are present. The substance on which they grow best is a mixture of beef broth and beef serum (obtained from the slaughterhouse) which has been coagulated by heat. This is called *Loeffler's medium.*

In moist material the bacillus is easily killed by heat since it forms no spores but it stands drying and exposure to light better than most disease-producing organisms. It may live quite a long time in saliva, deposited on dishes, tableware, toys, etc. Bits of membrane may be thrown out in coughing and dry on the furniture or floor. In these the bacilli may remain alive for several months and be distributed as dust. The bacilli are easily killed by disinfectants.

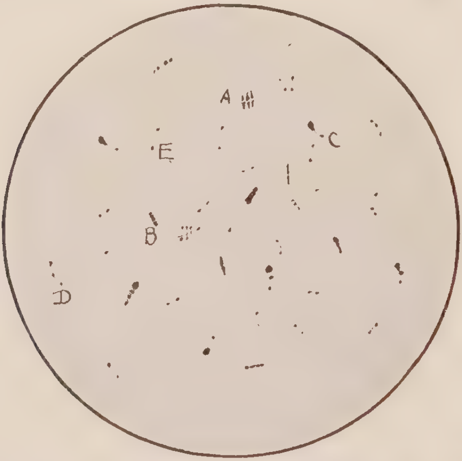


Fig. 36.—Diphtheria bacilli. A, Solid staining forms, showing "parallelism;" B, Barred form; C, Club shaped form; D, Beaded form; E, "Dumb-bell" form. Magnified 600 times.

The diphtheria bacilli, in an ordinary case of diphtheria, are not spread throughout the body, but remain limited to the throat, where they form a very powerful exo-toxin which is taken into the blood and injures the *various organs, especially the heart, nervous system, and kidneys.* This toxin is more powerful than the strongest drugs. The amount produced in a patch of membrane the size of the thumb nail, in the throat, may be sufficient to cause death. The symptoms of the disease are due to this poison, which is called diphtheria toxin.

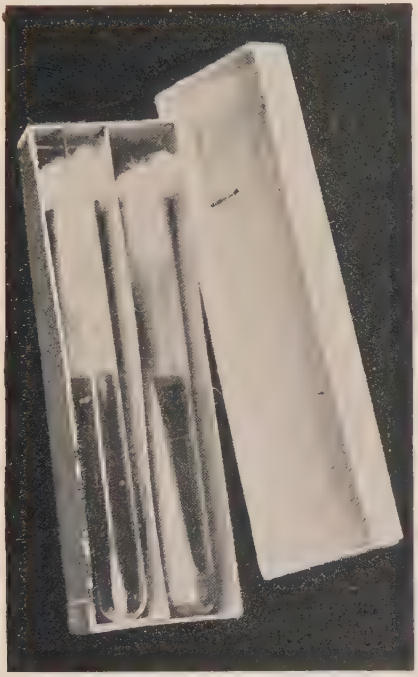


FIG. 37.—A Board of Health outfit for diphtheria diagnosis, consisting of a box containing a culture-tube and a tube of food substance. The swab is rubbed over the patient's throat and then immediately over the surface of the food substance, so that no time is lost in starting the culture (McFarland).

Diagnosis.—The bacilli are found in the throat in all cases of diphtheria, and often in the saliva and nasal discharge. The diagnosis is made by taking a small amount of material from the throat on the end of a sterile swab. The swab is then rubbed on the surface of Loeffler's medium and this is incubated for twelve to twenty-four hours. Stained smears are then made and examined under the microscope. Outfits for taking cultures are furnished by all health departments (see Fig. 37). The nurse frequently has to get these outfits, and before taking them she should look at the serum to see that it is still fresh and moist, as the bacilli will not grow on dry serum.

Diphtheria is spread by means of the saliva and nasal discharge, either by direct contact, as in kissing, or by coughing into another's face, or, as is frequently the case with children, by articles which go directly from the mouth of one child to that of another, as pencils, chewing gum, or drinking cups. Fingers may also carry the bacilli.

A second method of spreading the disease, even more important than by known cases, is by the so-called *"missed" cases;* that is, cases of true diphtheria in which the diagnosis is not made because the symptoms are mild or unusual. Some slight sore throats are due to the diphtheria bacillus, but this can be proved only by taking material from them on a swab as described above and making a culture of it. Hence a culture should be made from every case of sore throat, especially in schools and institutions, as one cannot always tell simply by looking at a throat whether it is a case of diphtheria or of ordinary tonsillitis. In children's wards the nurse should be on the watch for nasal discharges, especially those which irritate the nostrils or are tinged with blood, as these may be due to the diphtheria bacillus. A throat and nose culture is usually made as a matter of routine on each new patient admitted to a children's ward. Recognized cases of diphtheria are usually fairly well isolated, because every one is afraid of the disease; but no precautions are taken in the missed cases, and they go around scattering the bacilli.

A third way in which the disease is spread is by means of *carriers*. Diphtheria carriers were the first kind discovered, and much of our knowledge of carriers in general has come from the study of diphtheria. *There are three kinds of carriers of diphtheria* bacilli: (a) convalescents; (b) persons who have recently been in contact with diphtheria patients; (c) those who are not known to have had any association with the disease.

Convalescents usually get rid of the bacilli in from two to four weeks, but in some cases the bacilli may remain in the throat and nose for a long time after the patient has recovered. In about 5 per cent of the cases they persist for two months, and in about 1 per cent they remain indefinitely. Most health departments require *two or three negative cultures (that is, cultures which do not show the diphtheria bacillus) from both the throat and nose, taken at intervals of twenty-four to forty-eight hours, before a patient may be released from isolation.*

The second kind of carriers may be the schoolmates of the pupil who has been taken sick with diphtheria, members of the family, or the nurse who has had the care of him. These people are more dangerous than the patient or convalescent, because they go about freely; and it is they who are the hardest problem in the control of the disease, on account of the difficulty of detecting and of isolating them. The number of carriers of this kind depends on the strictness of the isolation of the patient, and the care taken in nursing and disinfection. It has been found that when no precautions are taken to isolate the patient, from 50 to 100 per cent of the members of the family become carriers; whereas, when such precautions are taken, only about 10 per cent become carriers. Carriers keep diphtheria alive in the schools, in which it is spread by various childish practices, such as putting pencils in the mouth, using each other's handkerchiefs, passing around candy, and taking turns on chewing gum. Healthy carriers do not as a rule keep their bacilli for more than a few days or a few weeks.

Any abnormal condition of the nose or throat—as adenoids, or enlarged tonsils—favors the persistence of the bacilli both in healthy carriers and in convalescents. *It also favors the lodgment of diphtheria bacilli and the development of the disease.*

When a case of diphtheria has appeared in a family, a school, or an institution, cultures are taken from the throats and noses of all persons who have been in contact with the patient. If any carriers are found, they are isolated until their cultures are negative. Carriers must observe the same precautions as are taken in actual cases of diphtheria to avoid scattering the bacilli by means of the saliva and nasal secretion.

The third class of carriers, those who have had no known contact with diphtheria cases, are discovered accidentally when throat cultures are made as a routine.

The Virulence of Diphtheria Bacilli.—The question of virulence of the bacilli is of the greatest importance in connection with diphtheria carriers. Not all diphtheria bacilli can cause the disease; that is, not all are virulent. Those which cannot cause the disease are harmless. It is possible to tell whether or not a particular culture is virulent by injecting it into a guinea pig, and all health departments are prepared to make this test. Guinea pigs are especially susceptible to virulent diphtheria bacilli. The test is generally called a "virulence test." Carriers of bacilli which cannot produce the disease are not dangerous; the carriers of virulent bacilli are those who must be controlled. The bacilli found in the throats of diphtheria convalescents and of persons who have been in contact with the disease are practically always virulent. These are, therefore, the dangerous carriers. The bacilli found in the throats of persons who are not known to have had any contact with the disease are frequently not virulent. Therefore, if isolation involves much inconvenience for these persons, the health department should be asked to find out whether or not the bacilli are virulent; if they are not, the carrier may be released.

The question of what to do about carriers of virulent bacilli is both important and difficult. Child carriers should of course be kept at home and away from other children, and precautions taken in the care of the secretions. If, however, the carriers are wage earners, it would be quite hard and unjust, as well as practically impossible, to keep them away from work unless it involved some special danger to others, as the handling of milk and food, the care of children, teaching, or nursing. In other cases the carriers are warned of the danger of spreading the bacilli, given definite directions about disinfecting their dishes and avoiding contact with others, and are allowed to continue their work. The health department keeps carriers under supervision to make sure that instructions are carried out. Every carrier should be required to have the nose and throat put in good condition, as that is the quickest and surest way to get rid of the bacilli.

A fourth way in which diphtheria may be spread is by *infected milk.* The diphtheria bacillus grows well in milk, and does not change its appearance or taste. The milk may be contaminated somewhere in its course from the cow to the consumer by means either of a healthy carrier, a person with a very mild unrecognized diphtheria who keeps on with his work, or by a convalescent who has returned to work while still carrying the bacilli. The bacilli are usually transferred to the milk by means of the hands, but they may occasionally come from milk bottles which have been returned from a home in which there is a case of diphtheria, and have not been sterilized before being refilled. Pasteurization kills diphtheria bacilli, but the *milk may be infected after it has been pasteurized.*

Epidemics of diphtheria due to milk are not rare. *The characteristics of any milk epidemic of any disease are that the cases break out all at once; that they are all on the route of one milkman, or among the customers of one dairy or firm; and that a majority of the patients are children.* This is true also of epidemics of scarlet fever and of typhoid caused by milk. The two most important agencies in spreading diphtheria are, however, the missed cases and the healthy carriers. Together they keep the disease going in a community.

Children under five years are the most liable to contract diphtheria, and it is more likely to be severe in them than in older children or in adults. From 80 to 85 per cent of all deaths from the disease are in children under five years. The number of cases of diphtheria and also of other contagious diseases of children rises rapidly in the fall, because bringing the children together in school increases opportunities for contact infection, and also because fall and winter are the seasons of indoor living and of slight infections of the nose and throat, which, allow diphtheria bacilli to settle down and start the disease.

Prevention.—Diphtheria used to be one of the most serious and dreaded diseases, but today we have all the knowledge necessary to prevent it absolutely. We have a test (the Schick test, which is perfectly analogous to the Dick test in scarlet fever) that shows which persons would develop diphtheria if exposed. There is also a method (the toxin-antitoxin injections) of producing *permanent active immunity* from the disease. (See Fig. 38.) The throat culture is a very reliable method of diagnosis, and antitoxin, if given in time, is a perfect cure. In spite of this, there are about 170,000 cases of diphtheria every year in the United States, and about one in every ten dies.

The preventive nursing of a case of diphtheria centers around the disinfection of the secretions from the nose and throat and of articles soiled by them, and the prevention of carriers. The principles are the same as for pneumonia or scarlet fever and they need not be repeated in detail. The dishes should be boiled, and the bed and body linen either boiled or soaked in disinfectant solution before it is washed. The nurse must take the greatest care in the disinfection of her hands. If the patient is treated at home, one person should be responsible for the nursing, and patient and nurse should be isolated from the rest of the family. With intelligent nursing and disinfection at the bedside, the

FIG. 38.

danger of caring for a diphtheria patient at home is not so much that members of the family will catch the disease, but that they may become *carriers*. It is advisable, therefore, whenever possible, to treat diphtheria patients in a special ward or hospital. After the patient has been released from isolation *terminal disinfection* of the room should be carried out as described in Chapter IX. (See also Section III, "The Prevention of Disease.")

The Use of Diphtheria Antitoxin.—*Diphtheria antitoxin was one of the earliest discoveries made in the study of immunity, and it is one of the greatest triumphs in the whole history of bacteriology.* Antitoxin first came into use about 1894, and it has saved an enormous number of lives. Diphtheria used frequently to be a fatal disease. In New York City in 1887 (before the days of antitoxin) there were about 10,000 deaths, while since its use has become general the rate has dropped so that in 1926 there were only 476 deaths.

The dosage of antitoxin is determined by the seriousness of the symptoms, the stage of the disease at which treatment is begun, and the age of the patient. The sicker the patient and the later the stage of the disease, the larger must be the dose. The danger is not in giving too much, but too little. Three thousand units may be sufficient

FIG. 38.—Permanent protection against diphtheria. Giving the Schick test and toxin-antitoxin injections in a public school in Brooklyn, N. Y. *a*, The nurse is sterilizing the skin of the forearm in preparation for a Schick test. *b*, The physician is injecting the toxin-antitoxin mixture into the skin. *c*, A positive Schick test showing that the child is susceptible to diphtheria. *d* (Right), The attendant is sterilizing the skin with iodin previous to immunization with toxin-antitoxin. (Left), The nurse is immunizing a child with toxin-antitoxin (Courtesy of Lederle Antitoxin Laboratories).

for an early mild case in a child, whereas a severe case in an adult would require 50,000 units. In desperate cases antitoxin is given intravenously. The antitoxin combines with the toxin circulating in the blood and renders it harmless.

If sufficient quantities of antitoxin are given early in the disease practically every case of uncomplicated diphtheria should recover (Fig. 39). *The success of the antitoxin treatment depends on counteracting the toxin by antitoxin before the poison has had the opportunity to injure the body cells.* The overwhelming importance of giving antitoxin early cannot be too strongly emphasized. *A few hours lost* in beginning treatment may make all the difference between life and death, or recovery with paralysis or a damaged heart and kidneys.

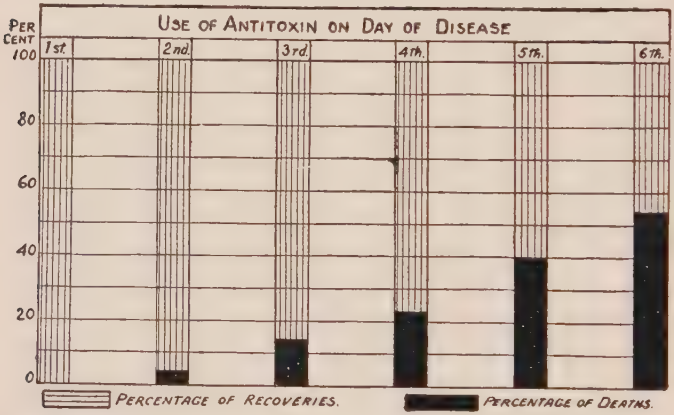


FIG. 39.—Showing how the chances of recovery from diphtheria are increased by the early use of antitoxin (From Reprint No. 778 from the Public Health Reports by Schereschewsky and Dyer).

A small dose of antitoxin (500–1000 *units*) *will prevent the development of diphtheria in those exposed to the* *disease.* This is called a *prophylactic* or *preventive dose*, and the protection given by it lasts only about four weeks. This is a good example of *temporary passive* immunity. Formerly a preventive injection was given to those intimately exposed to a case of diphtheria, as the nurse and members of the family; but now that we have a method of producing *lasting* immunity to diphtheria, antitoxin is given only to those who are in immediate danger of developing the disease, like children, and the others are immunized by the slower method of toxin-antitoxin.

The use of antitoxin is sometimes followed by symptoms which are spoken of as "*serum sickness.*" A few days after antitoxin has been given a rash sometimes appears often resembling the hives; in other cases there may be a diffuse redness, and there may be a rise in temperature and pains in the joints. These symptoms are not serious. They are not due to the antitoxin, but to the fact that horse serum itself is irritating to human beings.

The curative power of diphtheria antitoxin is measured in antitoxin units. The "*unit*" *of antitoxin* is the amount which counteracts a certain standard amount of toxin. This is tested on guinea pigs. The unit is used in measuring the doses of antitoxin just as minims and drachms are for ordinary medicines. A strong diphtheria antitoxin contains from 800 to 1200 units to the cubic centimeter.

In the United States the production and sale of diphtheria, as well as all other therapeutic sera, vaccines, etc., are regulated by law. The establishments in which it is manufactured are licensed, and samples of antitoxin, etc., are tested at the Hygienic Laboratory of the

United States Public Health and Marine Hospital Service in Washington. Antitoxin which falls below a certain standard of strength is not allowed to be sold.

The Prevention of Diphtheria.—(See under "The Prevention of Disease," Section III.)

CHAPTER XIX

THE TUBERCLE BACILLUS AND TUBERCULOSIS

Tuberculosis is one of the four most frequent and widely distributed of all infectious diseases, the others being common colds, measles and gonorrhea. Tuberculosis has declined a great deal of late years. In 1900 the deaths due to tuberculosis in the United States numbered about 200,000 while in 1927 the rate was only about 70 per 100,000 for the first quarter or about 80,000 deaths for the year. Between one and two million people in the United States have tuberculosis in some form or at some stage.

Tubercle Bacilli.—One of the most important discoveries in medicine was that of the tubercle bacillus, first seen and cultivated in the laboratory by Koch in 1882. It had been suspected for hundreds of years before the discovery of the tubercle bacillus, however, that the disease was infectious. Villemin produced tuberculosis in animals by inoculation with material from patients dead of tuberculosis.

Tubercle bacilli as seen under the microscope, are slender rods, often curved and having a beaded appearance. Tubercle bacilli are Gram-positive. The Gram stain, however, does not give as much information about them as some other stains. In fact, a special staining method is used, called the *Ziehl-Neelson stain.* Tubercle bacilli belong to a group of what are called *acid fast bacteria.* In staining them the following method is most widely used:

1. The smear is prepared as usual.
2. Flood with a solution of carbol-fuchsin a red dye (formula found in the larger text-books).
3. Heat the slide gently so that the solution steams. *Do not allow to boil. Do not allow to dry.*
4. After about 3–5 minutes, wash off the stain.
5. Apply alcohol which contains 3 *per cent hydrochloric acid*, for a minute or two. Wash.
6. Counterstain with methylene-blue.
7. Wash and blot.

The *acid alcohol* removes the red fuchsin from *everything except the acid fast* bacilli. These, then, retain the red stain while everything else appears blue (see Fig. 40). The reason for heating the slide is that the acid fast bacteria have a *waxy* cell wall. This must be softened so that the stain can soak in. Once in, it stays there in spite of the application of acid and alcohol.

The tubercle bacillus grows slowly in the laboratory, requiring about two weeks before its colonies are large enough to be seen with the naked eye. (Colonies of most other bacteria are visible in twenty-four hours.) It requires special media containing glycerine. It grows well on medium made of eggs or the heated serum of dogs.

It is more resistant to heat, disinfectants, and drying than most disease-producing bacteria. In dried sputum which is kept in the dark it may live from six to eight months. In particles of dried and powdered sputum which can float through the air as dust, it may remain alive for eight or ten days. It is also very resistant to dry heat, and in dried sputum can withstand a temperature of 200 degrees F. for one hour. Exposure to

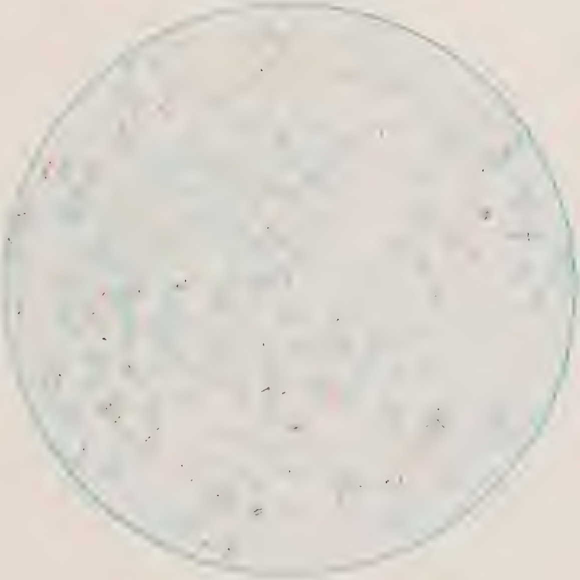


Fig. 40.—Tubercle bacilli in sputum, Ziehl-Gabbett; magnified 650 times. The bacilli have been stained red. The mucus and pus cells in the sputum are stained blue for contrast. Note the granular appearance of some of the bacilli, and their arrangements in clusters. The many bacilli pictured here are in a very tiny fraction of a droplet (Cornet and Meyer).

sunlight kills the bacillus in a few hours. It does not form spores.

It is difficult to kill the bacilli in sputum by means of disinfectants because of their waxy membrane and because they are protected by mucus. Complete disinfection of sputum with 5 per cent carbolic acid requires five or six hours. Bichlorid of mercury is unsatisfactory because it coagulates the sputum and therefore does not penetrate. Much the safest way is to collect the sputum in paper cups and burn it.

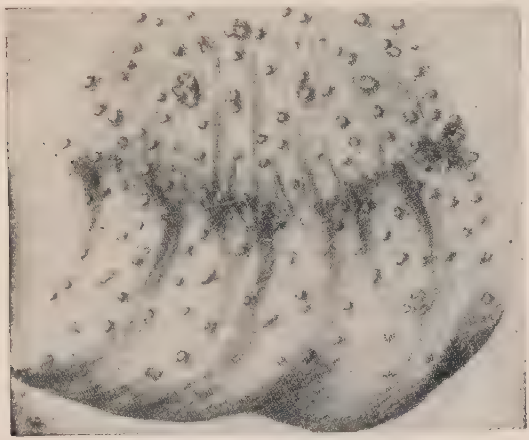


FIG. 41.—Tubercles of the peritoneal covering of the intestine and of the mesentery. About life size. (Ribbert.)

Tubercles.—Wherever tubercle bacilli locate in the body they cause a special kind of inflammation, different from that produced by other bacteria. We have seen that the diphtheria bacillus causes a characteristic inflammation in the throat, associated with a covering or membrane. The inflammatory reaction induced by the tubercle bacillus is called a *tubercle.* These tubercles are so characteristic that a diagnosis of tuberculosis can be made from them alone, even though the bacilli may not be found with the microscope. A single tubercle is a gray mass, the size of a

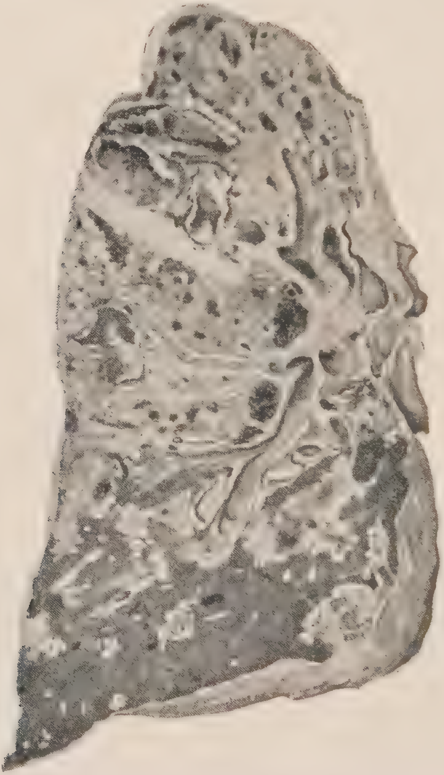


FIG. 42.—Pulmonary tuberculosis. The lung has been cut through the center and we are looking at a section. The section shows masses of tubercles. The cavities were formed by the softening of such masses, and the material was cast off as sputum (MacCallum, Text-book of Pathology).

pinhead or smaller, which feels hard to the touch (Fig. 41). Numbers of tubercles usually occur together in an organ (Fig. 42). The tissue which forms tubercles may soften and be cast out of the body. Tuberculous sputum and the pus from tuberculous abscesses is made up largely of the dead and softened tissue of tubercles.

Tubercles very frequently heal, in which case they become surrounded by thick envelopes of scar-like tissue, and lime salts may be deposited in them. As we shall see later, most of us are carrying healed tubercles somewhere in our bodies.

Whenever tubercles are present in an organ we say that tuberculosis of that organ exists. Every organ in the body may be attacked by tuberculosis, but in some it is much more frequent than in others. *In adults the lungs are the organs most often affected; while in children tuberculosis of the lymph glands, bones, joints, intestines,* and the brain and its coverings is more common.

Transmission of Tuberculosis.— The ways in which tubercle bacilli are cast off from the body depend, naturally, on what organs are affected. In tuberculosis of the lungs the *sputum* is the chief source of infection. In tuberculosis of the kidneys and bladder the bacilli may be present in the *urine* in large numbers. The germs are present in the feces in tuberculosis of the intestine, and in the pus from tuberculous abscesses.

The excretions of the tuberculous patient are the means by which the disease is spread, and the most important of these is the sputum, which is the source of danger in a great majority of cases. The sputum of consumptives may contain an enormous number of bacilli. It has been proved that a single patient who is raising a considerable amount of sputum may throw off in twenty-four hours 500,000,000 to 3,000,000,000 bacilli.

The bacilli enter the body through either the respiratory or the intestinal tract. A coughing or sneezing consumptive throws out a spray of sputum containing tubercle bacilli, and this may be breathed in by another person. In ordinary talking, however, there is little danger from infected droplets. Tubercle bacilli may also be inhaled in dust. If sputum is allowed to dry in open sputum cups or on handkerchiefs, floors, bedclothing, etc., the germs, which can remain alive for some time under these conditions, will be blown off by air currents and carried around as particles of dust. There is, however, less danger that this dust will be breathed in than that children will get it on their hands.

The bacillus may also enter the body through the mouth. Much of the tuberculosis in children comes in by this route. A careless consumptive contaminates the floor or furniture with sputum, or expectorates into the street. Children, creeping on the floor, playing around the room or in the street, will get the bacilli on their hands and so into their mouths. The hand-to-mouth transference of sputum probably accounts for many of the tuberculous infections of childhood. A single consumptive who continually expectorates when outdoors may be the means of infecting many people. As will be explained later children may also be infected by drinking the milk from tuberculous cows.

Food may be contaminated by handling it with fingers soiled with sputum, or it may be infected by flies which have crawled over tuberculous sputum. The common drinking cup or imperfectly washed spoon or fork may also carry the germs.

There is a difference of opinion as to whether infection occurs more often by breathing in infected droplets, or by taking in the bacilli through the mouth; but which theory is correct makes no practical difference. The great majority of cases contract the disease through *contact, direct or indirect, with a patient, by means of sputum in some form or other.* We already have sufficient knowledge to guide our preventive measures successfully.

There are **two chief kinds of tubercle bacilli.** The first and most important is the human kind, which is spread from man to man. It is the cause of pulmonary tuberculosis and of the larger proportion of all tuberculous infections. What has been said previously in this chapter refers to the human tubercle bacillus. The second kind, affects cattle as well as human beings. The two kinds of bacilli can be differentiated by laboratory tests. If a cow has tuberculosis of the udder, the milk will contain the bacilli. Children may be infected by drinking the milk of tuberculous cows, and this method of infection accounts for a certain proportion of tuberculosis of the lymph glands of the neck and abdomen, and also of the bones in children. Pasteurization kills tubercle bacilli. Adults are not often infected with the kind of tubercle bacilli found in cattle, but this kind is an important factor in the tuberculosis of children.

Farmers organizations all over the country are coöperating with the United States Government in an effort to get rid of tuberculosis in cattle.

The **diagnosis of tuberculosis** in any part of the body is made, whenever possible, by examining the appropriate excretion—sputum, urine, etc.—and actually finding the bacilli under the microscope. It is unsatisfactory to try to cultivate the bacilli, as is done in case of most other bacteria, because tubercle bacilli grow slowly and with difficulty in the laboratory. It is frequently necessary to make many examinations before the bacilli are finally found; therefore, *in suspicious cases one negative report is insufficient.*

When only a few tubercle bacilli are present in sputum, urine, pus, or other material, it may be impossible to find them with the microscope, and often the only method of discovering them is to inject a guinea pig with the material. If this contains tubercle bacilli, the animal will die from tuberculosis in from four to six weeks, and the bacilli will then be found in large numbers. In the case of urine, the *sediment* is usually collected for staining or injection.

Tuberculous Infection and the Disease Tuberculosis. Tubercle bacilli may remain alive in the body for many years without giving symptoms or doing any harm. The majority of adult and middle aged people have been at some time slightly infected with the tubercle bacillus, as signs of it are found in the lungs in many autopsies on persons who have died of other diseases, and who never had any symptoms of tuberculosis. This means that at some time tubercle bacilli have entered the body and grown there to a limited extent, but the defenses of the body have been strong enough to hold them in check. The bacilli are usually contained in the lymph glands along the trachea and bronchi. The glands become surrounded by thick coverings of connective tissue, as was mentioned above in speaking of the healing of tubercles. This connective tissue keeps the bacilli from getting out. In many people these glands are a storehouse for the tubercle bacilli, but the organisms never go any farther.

If at some later time the bacilli begin to multiply and are carried from the glands to other organs, as the lungs, where they set up an inflammation and produce sufficient poisons to cause symptons (fever, loss of weight, etc.), the disease tuberculosis is present. A large proportion of people over 40 years of age have had a *tuberculous infection*, but only a comparatively few develop *the disease tuberculosis*. It is of the utmost importance to understand these facts because they explain much in regard to the disease.

Infection often occurs during the first fourteen years of life. About 15 per cent of all children of 10 years are, or have been, infected. *Infection acquired during childhood may not cause the disease until years later*, the bacilli remaining alive in the lymph glands during all this time. *Children are most easily infected with tubercle bacilli*. In fact, if a child has been exposed to the disease in the family through association with a tuberculous patient, it may be assumed that he is infected. Adults, on the other hand, have resistance even to marked and long-continued opportunities for infection. Nurses in tuberculosis sanatoria do not develop the disease more frequently than those in other branches of nursing. There is small danger to adults from chance contact with a consumptive.

The probability is that many cases of tuberculosis in adults come not from a recent infection, but from a breaking down of the resistance of the body, which allows a childhood infection to start up. The bacilli, which have been living quietly in the lymph glands, escape from them into a more favorable tissue, take on renewed energy, begin to multiply, and thus cause active tuberculosis.

The discovery that *many cases of tuberculosis in adults have their starting point in an infection in childhood* has given an entirely different viewpoint and also a hopeful method of fighting tuberculosis; that is, the prevention of infection in childhood, and the special care of children who have been exposed to the disease.

Tuberculosis is a **family disease**; that is, it "runs in families," occurring in each generation. The reason for this is that the child is heavily infected in the home by tuberculous parents or relatives. Opportunities for the transfer of tubercle bacilli are numberless. The child plays on the floor and soils its hands with dust and dirt containing the bacilli. A consumptive mother cares for the child and prepares its food with hands contaminated with sputum. The infection thus received in early life may not break out into active tuberculosis until the child is grown up and has children of his own. They are then infected in the same way, and thus the story is repeated.

It is very unfortunate that the great majority of nurses have few opportunities during their training to become acquainted with this very common infection. Nurses who go into any kind of public health work after graduation are soon brought into contact with the disease and begin to realize its vast importance as a cause of disability, suffering, and death.

The Prevention of Tuberculosis.—See Section III, "*The Prevention of Disease.*"

CHAPTER XX

THE SPIROCHÆTA. SYPHILIS

There is a fairly large and comparatively little known group of organisms which bear the general name of *Spirochete*. These organisms are wavy or are spirally constructed. Some of the harmless species are much larger than bacteria. The spirochetes are regarded by many workers as being more like single celled animals than plants. It is generally agreed that they are probably not true bacteria.

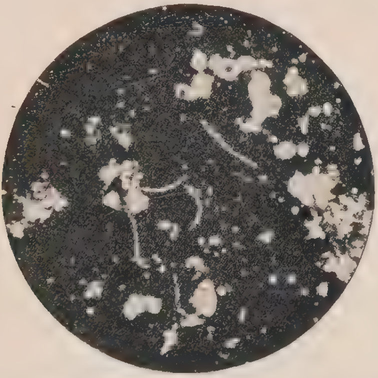


Fig. 43.—The Spirochæta pallida enlarged 1000 times. Dark field preparation made from chancre. The white blotches in the background are secretions from the chancre (J. C. Todd, Clinical Diagnosis by Laboratory Methods).

Spirochetes of various species live free in the outside world. Only a few species are harmful. Harmless spirochaetes are found in some drinking water supplies, oysters, the mouth, india ink, etc. Some of the spirochetes, especially the species causing syphilis, are not easily stained by ordinary methods. To demonstrate them, a special apparatus, called a "dark field," is commonly used. The directions for operating and the principles on which it is based are too complicated to discuss here, but may be found in textbooks of medical bacteriology. When organisms or particles are seen in the dark field they appear brightly illuminated against a dark back-ground, like dust particles in a beam of sunlight shining into a dark room. (Fig. 43.)

There are several species of spirochete of importance to man. The most important are listed below:—

Name	Disease Caused
Spironema vincentes	*Vincent's angina*
Spironema recurrentis	*Rat-bite (or relapsing) fever*
Leptospira icteroides (see figure 39; 1)	*Yellow fever*
Treponema pallidum	*Syphilis*

Vincent's Angina.—This is an infectious disease which usually attacks the gums and tissues of the mouth. There is a gangrenous ulceration with offensive odor. The spirochetes are found in enormous numbers in the ulcers, always associated with a long, thin, spindle- or cigar-shaped bacillus (see Fig. 44; 2). Both stain well with ordinary stains and the diagnosis may be made by staining material from the ulcers and examining it microscopically.

The disease is transmitted by drinking glasses, eating utensils, kissing and articles which come from an infected mouth. Vigorous disinfection of the mouth usually cures the infection. Arsphenamine, the same drug used for the treatment of syphilis, is also said to give prompt relief in many cases.

The organism itself is quite difficult to cultivate in the laboratory. It is anaërobic.

Relapsing fever is of interest chiefly to those in the tropics. It is seldom seen in the temperate parts of the United States. The spirochete can be transmitted normally only by the bite of rats and certain insects. It gets its name from the frequent and regular recurrences of the fever in the patient. It presents no nursing problems.

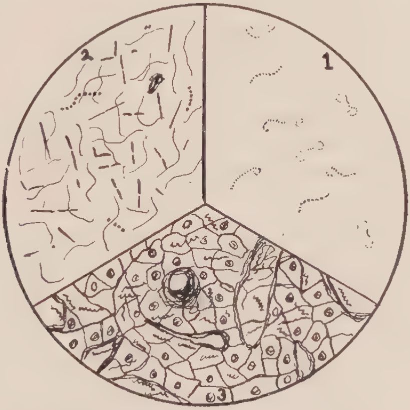


FIG. 44.—Various forms of spirochete. 1, Leptospira icteroides. The dotted appearance is due to the light reflected from each twist in the tiny coils; 2, Smear from case of Vincent's angina. Note the presence of long, thin bacilli in pairs and the Spironema vincentes. Note also the presence of a few streptococci and other bacteria; 3, Stained section of liver from syphilitic. Note the tiny spirochaetes scattered everywhere. They are Treponema pallidum. Magnified about 600 times.

Yellow Fever.—This is another tropical disease which formerly caused great loss of life. At present, due largely to the efforts of the Rockefeller Institute and the International Health Board, yellow fever has almost been stamped out. It is transmitted only by the bite of a certain species of mosquito. There are no special rules in nursing yellow fever.

The Spirochæta Pallida.—This organism, properly called the *Treponema pallidum*, is the cause of syphilis. It was discovered by Schaudinn in 1905. These spirochetes are slender, delicate, corkscrewlike organisms. (See Fig. 43.) The spirochete of syphilis, when examined in fresh preparations from syphilitic sores, is seen to be in active movement, gliding backward and forward and rolling from side to side. It has been described as "an animated corkscrew." It is spoken of as "pallida" because of its pale appearance under the microscope. It is not stained with ordinary dyes, but requires special and complicated methods for its demonstration in smears. It is most easily demonstrated in the living unstained condition by examining a drop of secretion from a syphilitic sore with a darkfield apparatus. (Fig. 43.)

Characteristics.—Not much is known about the life history of the spirochete. It grows with great difficulty in the test-tube, only under special conditions and in the absence of oxygen. It was first cultivated by Noguchi at the Rockefeller Institute. Growth is slow, as the colonies become visible to the naked eye only after two weeks' time.

The organism dies quickly outside the body as it is very sensitive to drying and to disinfectants. Soap is very fatal to the spirochaete. Any material that has dried will not carry the disease, but objects recently soiled or still moist with secretions containing the spirochete are possible sources of infection. The limit of life of the germs on ordinary objects is not more than six or eight hours. The disease is occasionally transmitted by towels, glasses, spoons, pipes, etc.; but the great majority of cases are acquired by direct contact with the infected person. **Syphilis** and tuberculosis are the most frequent *chronic infections.*

The Spirochæta pallida gains entrance to the body through breaks in the skin or mucous membranes, most often on the genital organs, occasionally on the lips, and causes an ulcer, called the *primary sore* or *chancre* (pronounced shank′er). This usually heals by itself after a time. But this does not mean the disease is cured. It simply means that the germs have left this particular spot and penetrated throughout the body. Within a few weeks after infection the spirochetes get into the blood and are carried to every organ in the body. (See Fig. 44; 3.) As a general rule, but not always, a rash appears, there are sores in the mouth and on the genitalia, sore throat, slight fever, and headache. This is called the secondary stage. Syphilis in this stage is an *acute infectious disease.* The ulcers and sores swarm with spirochetes, and the disease may be spread at this stage by the patient himself or by things still moist with his secretions.

These early symptoms disappear of their own accord after a number of weeks, but the disease is not cured; it enters on the chronic stage, called the third or tertiary stage. *Like the tubercle bacillus, the Spirochæta pallida may remain alive in the body for many years without causing any symptoms.* It may then attack almost any organ in the body. In the later stages of the disease there are long periods during which symptoms are absent, and the patient may believe himself cured. The disease then breaks out again. It is the cause of various diseases which appear a long time after the first infection, and go by other names than syphilis.

The late symptoms of syphilis depend on the organ which is attacked by the spirochetes, the heart and blood-vessels, the bones, the nervous system, etc. The most frequent, serious, and disabling results of syphilitic infection are *diseases of the heart, arteries, and nervous system.* These are frequent causes of early death in syphilitics. Syphilis is the cause of *aneurysm of the aorta,* of many cases of *disease of the aortic valves,* and it is frequently responsible for *arteriosclerosis and cerebral hemorrhage in comparatively young persons.*

Paresis, general paralysis, or dementia paralytica, and *locomotor ataxia,* or tabes, are both due to syphilis. About one-fifth of the patients in hospitals for mental diseases are paretics. The disease is always fatal sooner or later. In paresis spirochetes are present in the tissue of the brain; in tabes, in the spinal cord.

After the early symptoms have passed, the syphilitic is no longer infectious in the ordinary relations of life, although small numbers of spirochetes remain alive in the body. This is an important point for nurses to remember, as they are often unnecessarily afraid of patients in the later stages of the disease.

Congenital Syphilis.—A woman may transmit syphilis to her child if she has the disease at the time of conception or acquires it during pregnancy. The spirochetes pass from the mother through the placenta into the blood of the fetus. The baby is thus infected before birth and comes into the world with living spirochetes in its body. This is called congenital syphilis (congenital meaning present at birth).

Many pregnancies in syphilitic women end in *miscarriages* or *stillbirths*. Syphilis is the most frequent cause of the death of the fetus during pregnancy. The child may be born alive showing signs of syphilis or these may develop later. *Syphilis is a cause of much infant mortality.* Many cases of prematurity and marasmus are really due to syphilis. As in the case of adults, the spirochetes may remain alive in the child's body for a number of years without giving symptoms and then become active. After infancy, the most serious consequences of congenital syphilis are stunting of growth, diseases of the eye, deafness, epilepsy, and feeblemindedness.

Syphilitic babies with a rash and sores around the mouth and anus are infectious. There is practically no danger, however, from older congenitally syphilitic children.

About 5 per cent of patients in children's wards have congenital syphilis.

Wassermann and Kahn Reactions.—The blood of a person who has syphilis gives a special test, the Wassermann reaction, named after the German physician who discovered it in 1909. Serum of the patient is required for the reaction. Blood for the test is drawn from a vein at the bend of the elbow, at least 10 cc. being usually required. The reaction is too complex to describe here. It is too complicated to be carried out in small hospitals but it is done in special laboratories and in most health departments.

There is another test for syphilis, recently developed, called the Kahn test. This is simpler and quicker than the Wassermann test and is thought by many to be more reliable. It may eventually replace the Wassermann test. It has already been adopted by the United States Navy and some health departments.

The Wassermann and Kahn reactions are two of the most valuable aids which we now possess for the diagnosis of syphilis. The tests differentiate syphilis from other conditions which resemble it. A patient's blood serum may give a positive Kahn or Wassermann test many years after infection and it thus makes possible a diagnosis of the disease in persons who have had no visible signs for years. The reactions may become negative after treatment. This is a favorable sign, and repeated tests are therefore made to find out how the treatment is progressing. Congenitally syphilitic children usually have a positive reaction.

If the brain or spinal cord is affected by syphilis, the Kahn or Wassermann reaction is usually given by the *cerebrospinal fluid*. The reaction is practically always positive in paresis and frequently positive in locomotor ataxia.

Diagnosis.—The most satisfactory method of diagnosis in the first stage of the disease is the demonstration of the spirochetes under the microscope with the darkfield apparatus in fresh, unstained material obtained from the chancre or sores in the mouth or elsewhere (Fig. 43). These contain the organisms in great numbers. The Wassermann and Kahn reactions become positive only in the second or third week after the appearance of the chancre. They cannot, as a rule, therefore, be used for diagnosis in the very earliest stages, but later they are most reliable tests. It is very important to make the diagnosis before these reactions become positive in order that treatment may be started at once.

Arsphenamin. –There is a drug, arsphenamin, which kills the organism of syphilis. Arsphenamin contains arsenic, and is given intravenously through the vein at the bend of the elbow. The results of treatment in the early stages of the disease are remarkable. The spirochetes disappear, the sores around the genitalia and in the mouth heal very rapidly, and the Kahn and Wassermann reactions become negative. The effect of arsphenamin lasts only a short time, however, and treatment must be repeated at intervals over a number of years, in order to keep the patient noninfectious. The disease is by no means cured as soon as the early symptoms disappear, but treatment must be continued faithfully for years in order to kill all the spirochetes in the body. The chances of permanent cure diminish in proportion to the length of time which elapses between the time of infection and the beginning of treatment. It is of the utmost importance to get every syphilitic under treatment as early as possible, both for his own sake and that of the persons with whom he comes in contact. It is always difficult to be sure that a patient is entirely free from spirochaetes.

Prevention of Syphilis.—See Section III; "*The Prevention of Disease.*"

CHAPTER XXI

FILTERABLE (ULTRA-MICROSCOPIC) VIRUSES. SMALLPOX

It has already been indicated (Chapt. IV, Sect. 1) that there are organisms or substances of such nature that they will pass through the fine clay filters which are able to hold back even the smallest visible bacteria. (See Fig. 13.) All such organisms or substances are grouped together under the general name of *filterable viruses.* We have learned, however, that the action of the bacterial or porcelain filter probably has little to do with the size of the pores in the clay and depends on other things which are only partly understood at this time. The name filterable therefore, really does not convey much meaning, since by certain procedures bacteria can be made filterable or non-filterable at will. *Ultra-microscopic* is a much better term, and is coming into more general use. Ultra-microscopic means that the organisms are so small or of such nature that they cannot be made visible by even the most powerful microscopes.

The fact that we cannot see these viruses has made their study extremely difficult. Probably none of the truly ultra-microscopic viruses has ever been cultivated on artificial media. We are forced to study the diseases which they produce since we cannot study the organisms themselves. In this book no discussion of the actual organisms will be attempted.

Some of the common diseases produced by unknown or ultra-microscopic viruses are:

Measles
Mumps
Chickenpox
Smallpox
Infantile paralysis (anterior poliomyelitis)
Hydrophobia (rabies—"mad dog bite")
Sleeping sickness (lethargic encephalitis)
Common colds
Influenza

Only those printed in italics are discussed in this book.

Smallpox.—It is hard for us to realize today that smallpox was once the most prevalent and the most dreaded disease in the world. Before the days of vaccination ninety-five persons out of every hundred contracted it, and about one-fourth of those who took it died. Many of those who recovered were blinded or disfigured. It prevailed in China and other Eastern countries for many centuries before Christ, and has repeatedly swept over Europe in great epidemics. It is still frequent in uncivilized countries, especially those of the East, but owing to vaccination and the rigid enforcement of quarantine laws, it has decreased in most civilized countries.

In 1926 there were about 55,000 deaths in India due to smallpox as compared with 362 in the United States. In some countries, as England, there is an increase in smallpox. There were 315 cases in 1921 and 10,222 in 1926.

A peculiarity of smallpox is its change in virulence from year to year and from place to place. For example, in 1924–5, the death rate in Camden, N. J., was 40.3 per cent, while that in Detroit, Mich., in the same year was only 10.1 per cent.

Immunity to Smallpox.—It is a curious fact that although the cause of the disease is still unsettled, smallpox was the first disease to which immunity was obtained by artificial means. The method of protection was developed by practical experience, and was carried on more or less successfully for hundreds of years before there was any knowledge of the scientific principles on which it is based. Even before the time of Christ it was the custom in India and China to introduce under the skin of a healthy person a bit of pus from the eruption of a mild case of the disease, in the hope of producing a light attack. This procedure was called inoculation. The disadvantages of it were that the disease so produced was infectious, and the attack sometimes proved to be severe or fatal. Nevertheless, it continued to be practised until vaccination took its place.

Smallpox Vaccination.—The relationship between the mild disease cowpox and the dreaded scourge smallpox, has been pointed out in the chapter on immunity (p. 86). A person who has contracted cowpox from a cow is immune, for some little understood reason, to smallpox. Jenner, an English physician, noticed this and it occurred to him that if all people could be purposely inoculated with *cowpox*, then smallpox would no longer exist. He experimented along these lines and in 1798 published the results of his experiments. As a result, smallpox today is on the decline.

Jenner's methods were effective, but very crude. Modern methods of preparing vaccine are much superior in every way. This topic has been discussed in Chapter VII.

Modern Method of Vaccination.—The skin is washed with soap and water and then with alcohol, which is allowed to evaporate. The virus is expelled from the tube onto the skin, and with a sterile needle two punctures or scratches about an inch long (Fig. 45) are made through the drop of virus. Vaccination is a small surgical operation and should be done only by a person who understands surgical cleanliness. The wound may become infected like any other wound, and to this the complications of vaccination are due and also the bad results cited by persons who are opposed to vaccination.

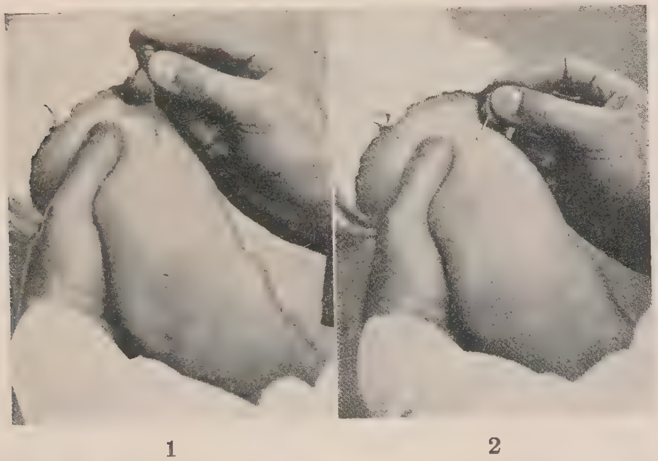


Fig. 45.—Vaccinating by the puncture method. 1. Expelling vaccine virus from capillary tube on to cleansed skin. 2. Making punctures with needle point pressed through drop of virus (Courtesy of Lederle Antitoxin Laboratories).

After vaccination there is an incubation period of three or four days, during which there are no noticeable changes. Then, if the vaccination "takes" an eruption appears at the place of inoculation and goes through certain characteristic stages, leaving a scar (Fig. 46). About the seventh day there is also a reaction on the part of the whole body lasting several

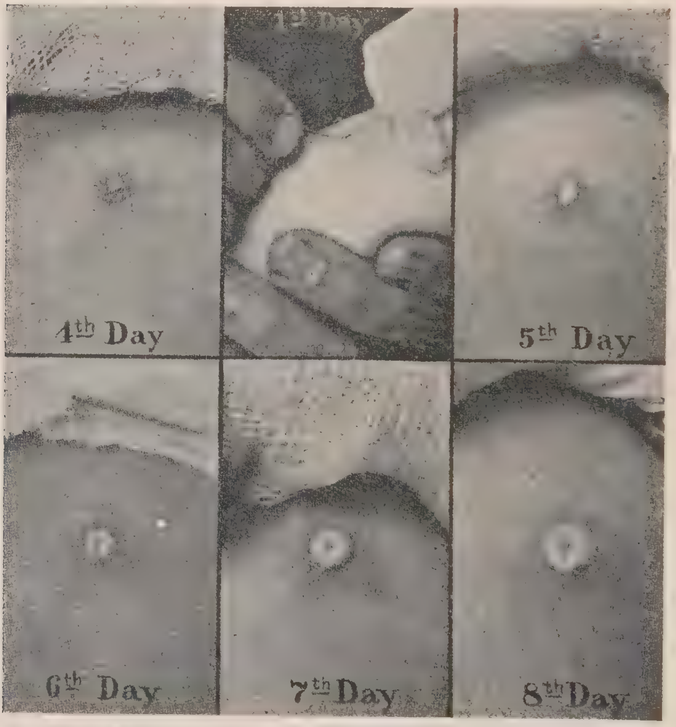


FIG. 46.—The course of the eruption in vaccination (From Rosenau, Preventive Medicine and Hygiene, D. Appleton & Company, Publishers).

days, shown by fever, loss of appetite, general discomfort, and headache. During this time substances are being formed in the body which will protect against smallpox.

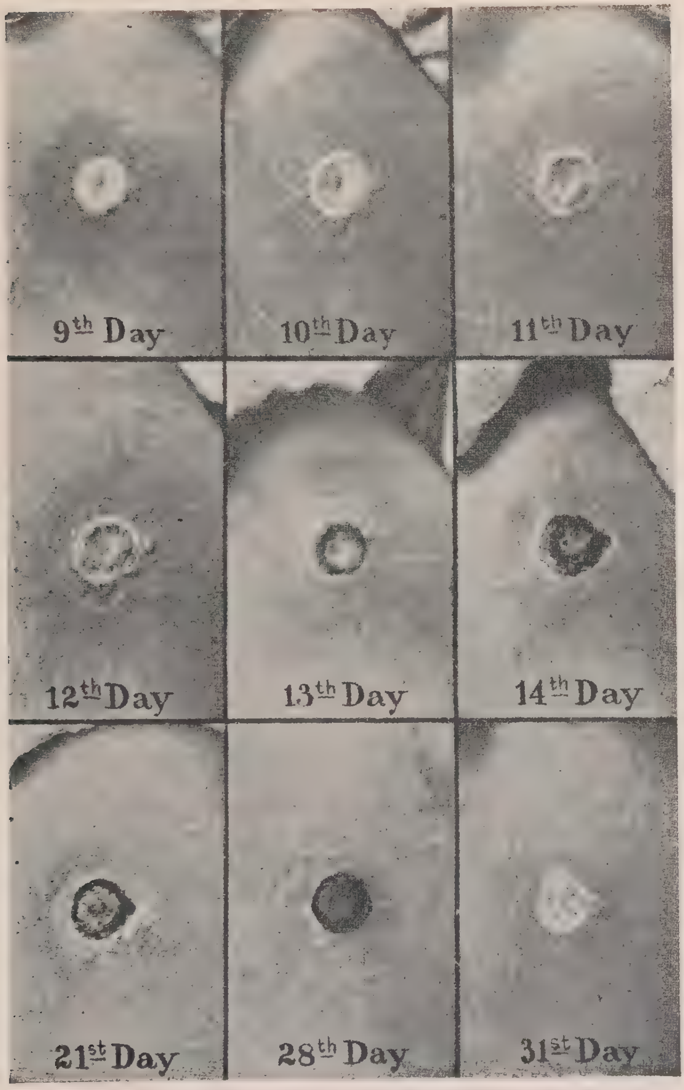


FIG. 46.—(Continued.)

Protection Given by Vaccination.—This is complete for some time and then it gradually fades. It usually begins to disappear in two years and is almost completely gone in ten years. Every child should be vaccinated between the ages of six months and two years and again when about twelve years old. Two vaccinations usually protect for life, but adults should be revaccinated whenever the disease appears in the community, or when they are going to places where it is present. It is usually true that if revaccination takes, a person is susceptible to smallpox; but if it fails, he is not necessarily immune, because the virus may have been weak or the vaccination improperly done.

Compulsory Vaccination.—*Smallpox can be absolutely prevented by the vaccination of a whole population.* There are many illustrations of this. The Philippines, before the American occupation, had, in seven provinces, more than 25,000 cases a year. In the year following vaccination by the United States Army authorities, of all the inhabitants (over 8,000,000), there was not a single death from the disease. Some years later, the native health authorities became careless in regard to vaccination and a terrible epidemic occurred. The carelessness of the health authorities cost the lives of over 50,000 people in a short time. Since then vaccination has been practised and in 1926 there were only about six deaths from smallpox in the Philippines.

Vaccination of Children Important.—If people are to be protected from the lifelong disfigurement caused by smallpox (and from death) they must be vaccinated before it is too late. Persons are susceptible to smallpox at all ages; therefore early vaccination of children is advisable. Vaccination is required in some states before a child will be admitted to school. It is regrettable that some communities do not realize the importance of this. Much disfigurement, sickness and death could be prevented by a rational view of vaccination on the part of those in control (see Fig. 47). Ignorance, false fears and politics are often responsible in pagan and uncivilized communities, but it is hard to believe that these factors control people in enlightened parts of the world.

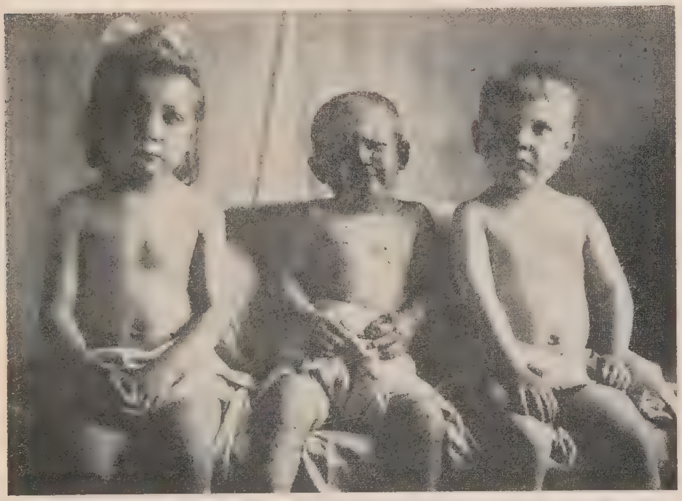


Fig. 47.—Children of one family who were brought to the Municipal Hospital of Philadelphia with the mother and father, who had smallpox. The child in the center had been considered too young to be vaccinated. The other children had been vaccinated a year before; they remained free from the disease, although for several weeks they lived in the wards of patients with smallpox (From Welch and Schamberg, Contagious Diseases, Lea & Febiger, Publishers).

Common Colds.—The true "common cold" usually starts with a "raw" or "scratchy" sensation in the posterior nares and pharynx. The nasal mucosa becomes acutely inflamed and a watery fluid is excreted copiously, accompanied by sneezing, watering of the eyes, headache, backache, and sometimes chills and fever. Unless complicated by some secondary infection the cold is usually of only three or four days duration and is seldom a dangerous disease in itself. They are, therefore, usually regarded lightly, but they are really a serious matter. The loss of time and efficiency on account of them mounts up to a tremendous total in a community. Still more important is the fact that the inflammation of the nose and throat which accompanies a cold prepares a favorable place for pneumococci, streptococci, diphtheria bacilli, and other organisms to lodge and set up a more serious disease. A cold may thus be a forerunner of pneumonia, diphtheria, and other infections. Furthermore, if a person who is carrying streptococci, pneumococci, diphtheria bacilli, or other disease germs in his throat has a cold, he will distribute not only the organisms causing the cold but also any other germs which he happens to have on hand. The victim will catch both the cold and also the other infection.

Transmission.—Rather close contact between person and person is necessary for the transmission of a cold. The nasal discharge and saliva carry the organisms, whatever they may be, and the ways in which the infection is spread are many—coughing, sneezing, kissing, carelessness about handkerchiefs, hands soiled with nasal secretion, imperfectly washed dishes, the common use of towels and drinking cups, etc.

Persons with colds are a real danger to others; but they are almost impossible to control, as they usually keep on with their daily work. A person with a cold should avoid any close contact with others, keep away from public places, cover the nose and mouth when coughing and sneezing, and avoid soiling the hands with saliva and sputum. A child with a cold should be kept out of school, both to avoid spreading the cold, and because the first symptoms of measles and whooping-cough are those of a cold. A person who has frequent colds should consult a doctor, for they may be due to enlarged tonsils, adenoids, or some condition which prevents him from breathing through the nose, and these should be remedied.

Causative Agent.—The cause of colds is a great mystery. There is good evidence that it is an ultra-microscopic and filter passing organism. The evidence is not conclusive, however, and some scientists believe colds to be due to physiological causes and not to any special living organism at all.

Influenza.—In 1918–19 a terrible epidemic of influenza swept over the entire world, causing about 10,000,000 deaths, and in the United States alone at least 450,000. Very little is known about this disease, although an immense amount of bacteriological work has been done on it. We do not even know whether it was the same as the infection which is called influenza or grippe in ordinary times, and occurs every winter as scattered cases or in small outbreaks. The mode of transmission of influenza is doubtful. Possibly crowded conditions, with droplet infection, favor epidemics.

We are still uncertain also as to the organism which causes the disease. Recently an extremely small germ, called Bacterium pneumoscintes, almost too small to be seen under the microscope, has been found in the nasal secretion of patients. This may possibly be the cause of the disease. There is also a small bacillus, which may be the cause, but probably is not. It is called B. influenzæ.

Epidemic influenza is one of the most contagious diseases known. When uncomplicated, it is a mild disease, but there is a special tendency to bronchopneumonia in connection with it. This is a dreaded complication, and it is responsible for most of the deaths from the disease. The same is true of ordinary grippe. The bronchopneumonia may be caused by pneumococci, streptococci, or the influenza bacillus. Thousands of deaths in the Army camps in 1918 were due to the bronchopneumonia accompanying influenza.

Public health measures, such as have been successful in controlling other infectious diseases, had absolutely no effect in the epidemic of 1918–19. Great influenza epidemics have occurred in nearly every generation for several hundred years, and it seems probable that in course of time history will repeat itself.

Although it is impossible now to prevent influenza or grippe, it is possible in the great majority of cases to avoid the complicating pneumonia by proper care: first, by putting the patient to bed promptly and keeping him there during convalescence; and second, by protecting him from the bacteria which are known to be the cause of the pneumonia. The latter is done by carrying out the same nursing precautions as are prescribed for bronchopneumonia.

Measles is one of the commonest diseases caused by living organisms. In spite of this fact, its cause is still unknown. In 1927 a Chicago physician, Tunnicliff, reported having proved a very tiny diplococcus to be the cause of measles. Her work is suggestive but as yet has not been fully substantiated. It has been proved, however, that the organism is present in the filtered secretions of the nose and throat and also in the circulating blood. The disease has been transmitted to monkeys by injecting them with the filtered nose and mouth secretions of human cases.

Measles is *extremely contagious*. If a person who has not had measles is exposed at any age, he is practically sure to catch it. The reason that the disease is chiefly confined to children is that most persons have had it before reaching adult life.

Transmission. The organism which causes measles does not live long outside the body. It is transmitted by direct contact, by droplet infection during coughing and sneezing, and by articles freshly soiled with the nose and mouth secretions. A very important fact is that the organism is present in the nasal secretion and saliva before the rash breaks out. The first symptoms of the disease resemble those of an ordinary cold, and the rash does not appear until three or four days later. The disease is most infectious during this early stage; there is little danger of the patient's giving the disease after the temperature has returned to normal.

Complications. Measles itself very seldom causes death, but complications are frequent and may be very serious or even fatal. The most common of these are bronchopneumonia, caused by pneumococci or streptococci, and abscesses in the ear, caused by streptococci. Measles may also reduce the resistance of a child so that it falls a victim to tuberculosis.

Measles is usually regarded lightly, but it is really a serious disease on account of the infections which accompany or follow it. The number of deaths due to measles is much larger than is generally realized. In the United States in 1925 it was responsible for over 2300 deaths. As with diphtheria and other infections, the younger the child, the more serious the disease. Less than half of the *cases* occur in children under five years, but 95 per cent of the *deaths* are in children of four years and under.

The number of deaths from measles is much greater among the poor than among the well-to-do, because children in comfortable homes have better nursing, are better nourished, are not overcrowded, and usually do not catch the disease at such an early age. In institutions, also, where numbers of frail young children live in close contact, an outbreak of measles is a serious matter.

Good nursing is of the utmost importance in measles to prevent the occurrence and spread of the complicating infections. Cleanliness of the nose and mouth will do much to ward off infection of the ears and lungs. If measles cases are treated in wards, the most rigid precautions must be taken to prevent the spread, not only of droplets, saliva, and other materials containing the measles organism, but also of streptococci and pneumococci from one measles patient to another. These precautions and the care of the mouth have been discussed in connection with bronchopneumonia. Terminal disinfection is not necessary for the short-lived measles organism, but streptococci are vigorous and long-lived. It is better, therefore, to sterilize the bedding and clothing, and to give the room a thorough cleaning with soap and water following measles.

Mumps.—The organism causing this disease is unknown, but it is spread by the secretions of the mouth, nose, and throat. The disease is difficult to control because the incubation period may be as long as three weeks, and the patient may give the disease for some time before the symptoms appear.

Chickenpox.—This disease is included here, although the ways in which it is spread are uncertain. The organism causing it is also unknown, but it is contained in the "pock," or eruption.

Hydrophobia (Rabies).—Hydrophobia is derived from two Greek words, *hydro* and *phobia*, which mean respectively, *water* and *fear*. Hydrophobia is a fear of water. Dogs, which are in an advanced stage of rabies can neither eat nor drink because the muscles of the tongue and throat are paralysed. The attempt to drink, indeed the very sight of water or food, causes the most painful spasms of these muscles, and hence the animals are afraid of water and even of food.

Rabies is a horrible disease when contracted by human beings. Death is practically inevitable and is always attended by the most fearful, lingering agonies and mania. Ninety-four deaths due to rabies were reported from 26 states in 1925. The organism causing rabies is unknown. It is known to occur in the brain, spinal cord and saliva of rabid persons and animals, and the disease can be easily transmitted by injections of the saliva or brain material. There have been described, in stained sections of the brain of rabid animals, certain bodies, called *Negri bodies* after their discoverer. Whether these are the organisms which cause the disease is still unknown.

When a person is bitten by a dog suspected of being mad, the bite should be burned out (cauterized) either with a hot iron or with concentrated nitric acid. The Pasteur treatment should be started without delay. *Do not kill the dog unless it is diagnosed rabid by a competent veterinarian.* If it is caught, hold it for observation for at least two weeks. If it has rabies, it will show symptoms and may then be killed and the brain examined for Negri bodies. If it shows absolutely no symptoms, it may be released and the victim may then discontinue the Pasteur treatment. His mind will be much more at ease to know the dog to be free from rabies than if the dog had been killed with the suspicion still upon it.

Pasteur treatment reduces fatality from nearly 100 per cent to about 1 per cent. It is absolutely harmless.

CHAPTER XXII

INSECT-BORNE DISEASES. MALARIA

A number of diseases are transmitted by insects of various kinds. Usually only one disease is transmitted by the bite of a given kind of insect. Some insects, and especially house flies, do not bite but may carry disease germs upon their feet and bodies and may deposit germs in fecal material called "fly specks." The diseases carried by flies have been discussed in an earlier chapter. The commoner diseases carried by biting insects may be tabulated as follows:—

- *Mosquitoes*—
  - Malaria,
  - Yellow fever.
- *Bed-bugs*—
  - Relapsing fever (?)
- *Ticks*—
  - Relapsing fever,
  - Rocky mountain spotted fever,
  - Texas fever.
- *Rat fleas*—
  - Bubonic plague.
- *Lice*—
  - Typhus fever.

The extermination of rats, flies and biting insects of all kinds is therefore desirable from a sanitary standpoint. Extermination is not always possible but it is always feasible to keep insects and rats out of our houses and away from our bodies by simple measures of screening, fumigation, and cleanliness. The most important and the commonest insect-borne disease in the United States is malaria. It is the only one which will be discussed in this chapter.

Malaria.—Nurses in the tropics and in all warm climates become very familiar with this disease. It is present in temperate climates all over the world, and in the past it has made some parts of the earth, like Panama, almost uninhabitable. The countries where it prevails have, within recent years, been fighting it on a large scale. Due to the efforts of the International Health Board and the Rockefeller foundation, malaria has been very much reduced in recent years. In 1925 there were about 100,000 cases, whereas formerly it was not uncommon for over a million cases to be reported in the U. S.

The Malarial Parasite.—The disease is caused by a very simple form of animal life called the malarial parasite (see Chapter on Protozoa). A parasite is a creature which lives on another creature, getting its food from it but giving nothing in return. Man and other animals are afflicted with various parasites. The bacteria which live on and in the body are parasites, and so are lice and tapeworms. The creature on which the parasites live is spoken of as the *host*, although his guests are neither welcome nor paying.

The life history of the malarial parasite is quite complicated. It has two stages of existence, one of which is passed in the human body, the other in the mosquito. Both man and the mosquito are hosts of the organism, and both are necessary for its life and reproduction. Unless it can pass from man to the mosquito, and from the latter back again to man, it will die out. It is transferred from man to the mosquito and back again through the bite of the mosquito.

Life in Man.—The mosquito, in biting, injects the parasites into the blood of its victim through its bill, which is a sort of natural hypodermic syringe. The parasites immediately enter red corpuscles and grow within them (Fig. 48). The parasite within the corpuscle is in active movement. It multiplies within the red cell into a number of small bodies or segments. Finally the affected corpuscle breaks up, and the segments escape into the circulating blood. Each segment is a new, active parasite and no sooner gets out into the blood than it attacks another red corpuscle and in turn multiplies. In this way the blood is soon teeming with the parasites and the patient becomes anemic and weakened from the loss of so many red corpuscles and from the poisonous products formed by the parasites.

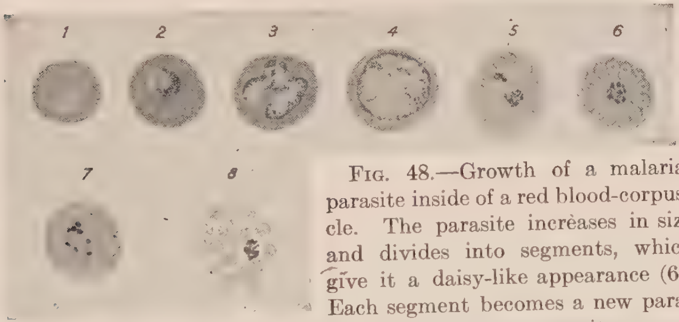
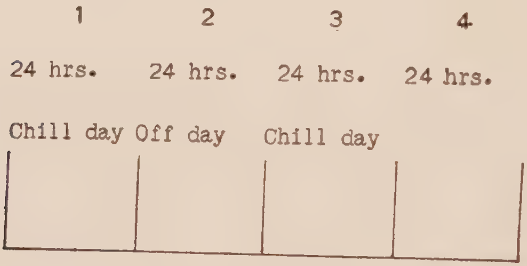
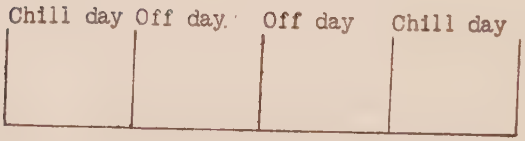


Fig. 48.—Growth of a malarial parasite inside of a red blood-corpuscle. The parasite increases in size and divides into segments, which give it a daisy-like appearance (6). Each segment becomes a new parasite. Finally the red corpuscle bursts and the young parasites escape into the circulating blood (8). This is when the chill occurs. They are now ready to enter fresh corpuscles. The black material is pigment formed from the hemoglobin of the red corpuscle (Thayer and Hewetson).

The parasites are present in the blood in great groups, all the individuals of which divide and burst out of the corpuscles at about the same time. This process causes the chill and fever. A chill means that a fresh crop of parasites has matured and entered the circulation.



Tertian Malaria



Quartan Malaria

FIG. 49.—Diagram of the occurrence of chills in tertian and quartan malaria.

There are three forms of the malarial parasite. The first and most common requires forty-eight hours to complete its development within the red cells. The chill will therefore occur at intervals of forty-eight hours, or every third day. This is called *tertian* (*third*) *fever*

(Fig. 49). The second form of parasite requires seventy-two hours for development, and crops ripen every fourth day. This kind, which is comparatively rare, causes *quartan (fourth) fever.* The third form, *estivo-autumnal,* requires from twenty-four to forty-eight hours for development. The temperature curve of this fever is irregular, and chills may occur every day or be entirely absent. It is called estivo-autumnal because it occurs in the late summer and fall. It is more severe than the other forms of malaria and is less easily controlled by quinin.

Not infrequently a person may be infected with two or even three types of parasite and have chills every day, or two days in succession and then skip a day and have two more days of chill, and so on.

Life in the Mosquito.—When a mosquito bites a person who has malarial parasites in his blood it takes these in with the blood which it sucks. The parasites undergo further development in the wall of the mosquito's stomach, a stage of development impossible in man but necessary for the continued existence of the parasite. Finally, after multiplying and moving about for some days inside the mosquito, they reach the mosquito's salivary glands and from there are injected into man when the insect bites. The circle is thus complete. The period of development of the parasite in the mosquito is about twelve days; that is, a mosquito which has bitten a malaria patient cannot transmit the disease to another person until the end of that time. A mosquito once infected remains so for the rest of its life, which may be two months or more.

The Malaria Mosquito.—There is only one kind of mosquitoes which can carry malaria. This kind is called the Anopheles mosquito. Only the female mosquito bites mankind.

The Anopheles mosquito may be recognized as she bites. First, she stands in a position like that indicated in Fig. 50*a*. The harmless mosquito stands as shown in Fig. 50*b*. The Anopheles mosquito usually has markings or spots of silver or gray on the wings and often gray bands on the legs. There are several varieties of mosquito and the markings are not as plain on some as on others. The harmless varieties are brownish or brown-gray.

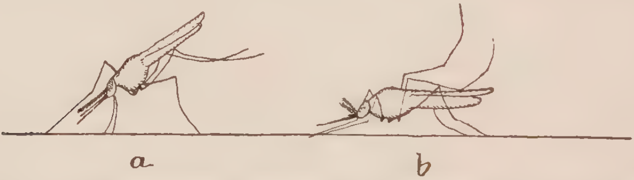


FIG. 50.—Characteristic attitudes of mosquitoes at rest: *a*, The malaria mosquito with body at an angle to the surface; *b*, the harmless mosquito with body parallel to the surface (Deaderick, A Study of Malaria).

Anopheles mosquitoes are recognized by a number of other means. Their eggs and young offer points for recognition. Students interested are referred to the larger textbooks.

Diagnosis of Malaria.—The laboratory diagnosis of malaria is made by spreading a small drop of the patient's blood on a slide and staining it with Wright's stain, a special stain used for blood smears. The parasites can be seen in or upon the blood cells and may have any of the appearances seen in the illustration, depending on the stage of their development in the red cells.

The Prevention of Malaria.—See Section III, "The Prevention of Disease."

CHAPTER XXIII

PROTOZOA PATHOGENIC FOR HUMAN BEINGS

Protozoa. The protozoa (proto = primitive; zo = animal) are single celled animals. They bear a relation to the animal kingdom similar to that of the bacteria to the vegetable kingdom. Their life activities and their structure are somewhat more complicated than those of the bacteria and they are, in general, considerably larger than the bacteria. There are hundreds of kinds of harmless protozoa living in much the same situations in the outside world as are the thousands of varieties of harmless bacteria. Only a relatively few kinds of protozoa are harmful to man and it is the more important of these that we shall describe very briefly in this chapter. Students interested in learning more of the protozoa should consult one of the larger textbooks on medical bacteriology.

Structure and Biology in General.—The protozoan cell resembles the diagram shown in Chapter I much more closely than does the bacterial cell. There is always a well defined nucleus, which can be seen clearly with the microscope. There is a definite cytoplasm and cell wall and there are usually other small granules which can be seen and which have various functions connected with motion, digestion, reproduction, etc. *Protozoa multiply* very much as do bacteria; that is, by dividing into two. They usually divide lengthwise rather than crosswise like the bacteria.

Many of the protozoa pass through a series of stages in their development and thus differ greatly from the bacteria. These *life cycles*, as they are called, differ for each species and often are exceedingly complicated. A very good illustration of a protozoan life history is that of the malarial parasite which is a protozoan. (See Chapter on Malaria.) In the case of the malarial and some other protozoa, especially those which live in the blood, it is necessary for the parasite to live on one or more insect hosts before it is mature and ready to infect man and reproduce again. The insect is called the *intermediate host.* In the case of malaria the intermediate host is the Anopheles mosquito. Usually protozoa multiply during one stage of their life cycle by sexual means. This differs with different organisms. All of the protozoan parasites of man which we shall study in this chapter are motile. The means of motility is different in each group and is used as a basis of classification

Classification.—There are four great groups of protozoa. At least one member in each group attacks mankind. They are as follows:

CLASS I. RHIZOPODA (move with pseudopods).
    A. Entameba histolytica—causes amebic dysentery.
CLASS II. MASTIGOPHORA (move with long, whiplike lashes called *flagella*).
    A. Intestinal parasites.
        1. *Giardia intestinalis*—causes mild diarrhea and ulcers of intestine.
        2. *Trichomonas hominis*—causes mild diarrhea (?).
    B. Blood parasites.
        1. *Trypanosoma rhodesiense*—causes African sleeping sickness.
        2. *Trypanosoma gambiense*—causes African sleeping sickness.

CLASS III. SPOROZOA—(move with flagella in immature stages only).
  1. *Plasmodium* (*vivax, malariæ, falciparum*)—cause different types of malaria. (See Chapter on Malaria.)

CLASS IV. INFUSORIA—(move with cilia).
  1. *Balantidium coli*—causes mild diarrhea (?).

Entameba Histolytica.—The *Entamebæ* are one sort of the large group of organisms called *amebæ.* These organisms have no particular form, but are continually changing their shape from round or oval to very irregular shapes with protrusions and finger-like processes sticking out from various portions. They move by means of these finger-like processes which are called *pseudopodia* (pseudo = like; pod = foot).

There are several types of amebæ which live in the intestine. The harmful type bears the name given above. This organism feeds upon the cells which line the intestine and upon red blood corpuscles. They feed in exactly the same manner as do the leucocytes, and indeed resemble the leucocytes in many respects. They have the power of causing a severe form of dysentery called *amebic dysentery,* and of causing great ulcers in the intestine. They often burrow through the lining and perforate the intestinal wall and the patient may then die of peritonitis caused by escape of the bacteria in the feces into the abdominal cavity. The entamebæ often migrate upward into the liver and burrow through the diaphragm into the lungs, eating out huge cavities wherever they go. The patient usually does not survive such injuries. Early treatment is necessary and usually simple and effective.

Transmission and Diagnosis, Carriers.—The organisms are voided in the feces. They have the property of forming spore-like cysts which remain alive for some time in feces or in polluted soil or water or dust. Anything contaminated with infected human feces may transmit the cysts. This is an especially common occurrence in the orient and other places where human sewage and feces are used for fertilizer. Fresh vegetables, as lettuce, celery, etc., may then very readily have live amebæ cysts upon them when eaten.

Carriers of *E. histolytica* exist in all populations and these of course are dangerous sources of infection. In countries where modern sanitation in regard to disposal of sewage and feces is effective little amoebic dysentery exists.

The disease may be diagnosed in the laboratory by examination of the stools of a patient with the microscope. The cysts and vegetative forms may then be found.

The amebæ are easily cultivated on certain special media.

Giardia Intestinalis.—These organisms have a very fantastic appearance. It is shown in Fig. 51; C, C′ and D. They are about the size of the smaller leucocytes. They live in the intestine and fasten themselves to the cells which line it by means of a sucker-like organ. They feed on the body fluids.

Giardia intestinalis causes mild diarrheas as a rule and may often be found in perfectly normal people. It is not a very dangerous organism. Like the amebæ it can form cysts and is disseminated with fecal material. Diagnosis is made by examination of the stools with the microscope.

Trichomonas Hominis.—These are pear shaped protozoa which are a little smaller than Giardia intestinalis. They do not cause any very severe lesions in the intestine and indeed it is questioned by many if they are harmful at all. They are capable of forming cysts and are disseminated in the feces. (See Fig. 51; E.)

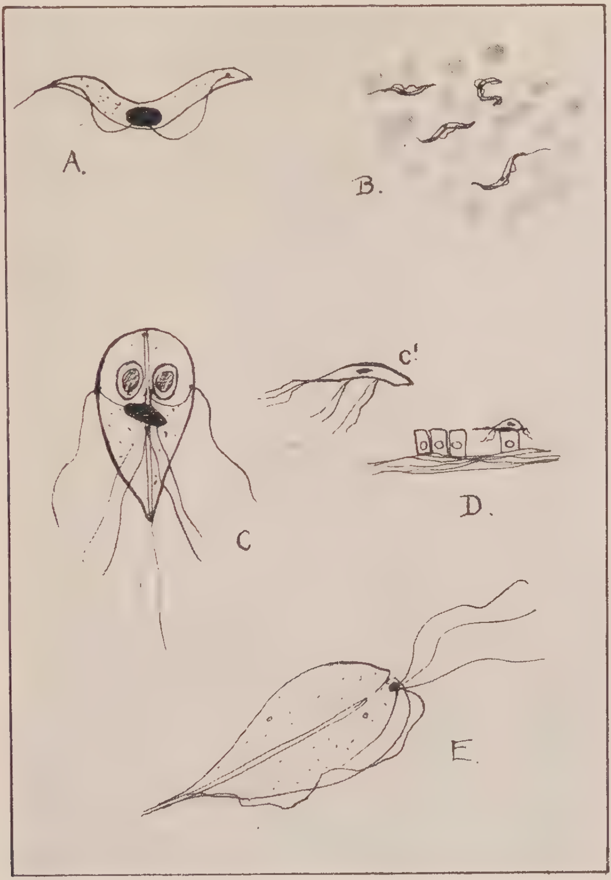


FIG. 51.—Various forms of protozoa. A, Trypanosome. (Enlarged about 2500 times); B, Trypanosomes in blood. Magnified 600 times; C, Giardia intestinalis (diagram); C′, Giardia. (Side view, showing concavity); D, Epithelial cells in intestine showing how Giardia attach themselves; E, Trichomonas hominis (diagram).

Treatment is easy and effective for both Giardia and Trichomonas infections. Carriers of both organisms are not uncommon.

The Trypanosomes.—The *trypanosomes* are rather elongated and pointed organisms and have the appearance shown in Fig. 51. The most important species in human disease are those which cause African sleeping sickness, (*T. gambiense and T. rhodesiense*).

The trypanosomes live in the blood and are transmitted from person to person only by a biting fly called the *tsetse fly*. The fly acts as an intermediate host and the trypanosomes undergo a portion of their development in its body.

The disease is limited to Africa and is found especially in the provinces of Gambia and Rhodesia, whence the organisms take their names.

Prevention of the disease depends on elimination of the tse-tse flies and certain wild animals which act as carriers, since cures are not very effective and the infected person usually dies.

Plasmodium Vivax: Plasmodium Malariæ: Plasmodium Falciparum.—Malaria has been discussed in a special chapter. The names of the three types of malarial parasite are given above. P. vivax causes tertian, P. malariæ causes quartan, and P. falciparum causes estivo-autumnal malaria.

Balantidium Coli.—This is a pear-shaped organism about the same size as Trichomonas hominis. It moves about by means of cilia protruding from its body at all points.

Balantidium coli is thought to cause mild intestinal disturbances at times. Its relation to any serious disease is very doubtful. It is found and transmitted in the feces.

CHAPTER XXIV

YEASTS AND MOLDS

Molds.—Everyone is familiar with the green, brown, black or white growths often seen on stale bread or jars of jelly or on old rags which have lain in a damp place for a long time. These growths are molds. If such material be examined carefully with a magnifying glass, it will be seen to consist of a most beautiful, almost fairy-like plant. Tiny roots penetrate into the substance on which it grows. The stems and branches, all are glistening and transparent. Each branch consists of many cells arranged end to end. (See Fig 52; B.)

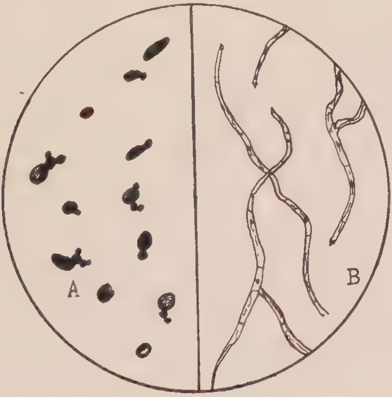


FIG. 52.—A, Yeast cells showing budding; B, Mold filaments. Magnified 600 times.

The fruit (spores) is usually deeply colored and grows in great profusion. Each little colored ball is a spore or a mass of spores.

Molds may be said to resemble bacteria in being very lowly forms of plant life. Their colonies, however, as described above, are quite different. The spores of molds are distributed, like bacterial spores, by the wind and are always present in dust.

Practical use is made of molds. In cheese making, for example, the action of particular species of mold gives characteristic color, odor and flavor to the cheeses.

There are a few species of mold which cause disease in human beings. A list of some of the molds, with the disease caused by each, is appended. The mode of transmission of mold diseases is rather obscure. Actual contact with skin lesions caused by molds may be sufficient, especially if there be abrasions in the skin.

DISEASES CAUSED BY MOLDS

Name of mold	Disease caused	Mode of transmission
Microsporon furfur.	*Pityriasis:* Not a dangerous disease. Brownish-red spots.	Not definitely known. Often occurs on persons with delicate skin and in those who perspire freely and who are not over-clean.
Achorion schönleinii.	*Favus:* A scalp disease resulting in baldness.	Not definitely known. Often thought to be carried by pet animals such as dogs or cats.
Trichophyton (various kinds).	"*Ring-worm*" (Tinea): Occurs on scalp, face, hands and elsewhere.	Direct contact with the lesions. Often thought to be contracted from pet dogs, cats and horses.
Sporothrix.........	*Sporothricosis:* Invades tissues, producing lesions which resemble tuberculosis in some respects.	Pus from lesions contains the organisms.

Favus and *sporothricosis* may extend deep into the body and fatal cases have been reported in each disease. The diseases caused by molds are very stubborn as a rule and often resist treatment for a long time.

Yeasts.—Nearly everyone is familiar with the baker's yeast cake with its peculiar odor. How many are aware that these cakes contain countless numbers of single-celled plants? This is actually the case. The yeast plant resembles the bacteria in having a relatively simple structure, in being round or oval, and in its ready multiplication on ordinary food substances by the simple process of division. Yeast cells, when they multiply, usually divide into a large part and a small part called a "bud." The process is often called "budding." Yeasts form spores, much like bacteria. The yeast cell is 20–40 times as large as most cocci. (See Fig. 52; A.)

Yeasts very readily use various kinds of sugar or starch as food. They give off enzymes which bring about the chemical changes in sugars and starches called *fermentation*. In fermentation by yeast, two products are commonly formed; alcohol and a gas called carbon dioxide. Both of these are found in beer, new wine and raising dough. The holes in bread are due to the gas bubbles. The foam on beer and the effervescence of champagne are also due to the carbon dioxide formed by the yeast.

There are a few yeasts which cause disease in man. They are tabulated below. Most of the pathogenic yeasts differ greatly both culturally and morphologically from baker's yeast, especially when growing in the body tissues where they often resemble molds in appearance.

DISEASES CAUSED BY YEASTS

Name of yeast	Disease caused	Mode of transmission (Aside from directly coming into contact with the lesion.)
Oïdium albicans also called *Monilia albicans*..........	*Thrush. Sprue.:* Invasion of tissues of mouth, throat, stomach, lungs, etc., by the yeast-like organism. Often fatal.	Unknown.
Cryptococcus Several species: *hominis gilchristi, Saccharomyces tumefaciens* and others.	*Blastomycosis:* Ulcers on skin, or abscess in bone or tissues of various parts of the body. Usually fatal.	Unknown.
Torula meningitidis.......	*Meningitis:* Inflammation of the coverings of brain and spinal cord. Fatal.	Unknown.

SECTION III

The Prevention of Disease

Public Health Aspects of Bacteriology

CHAPTER XXV

THE PREVENTION OF TUBERCULOSIS

We have learned in a previous chapter how bacteria are cast off from one person and carried to another. We have also seen that by taking certain precautions, a great deal of infection may be prevented in the ward, the sick-room, operating room and home.

In recent years, efforts of scientists and public health authorities have been directed toward the prevention of infection in whole communities, and, indeed, to the absolute stamping out of disease in the world at large. The task has only commenced. Much has been done, but more still remains.

One of the most widespread diseases, and one with which public health measures have been especially concerned is tuberculosis. We shall therefore discuss this first.

The prevention of tuberculosis is of immense importance to the human race. Indirectly, tuberculosis enters into many public health questions and activities and social problems.

We emphasized in a preceding chapter the fact that an infection acquired in childhood may be held in check for many years by the defenses of the body, although the bacilli remain alive in the lymph glands. It is also found very frequently, in making autopsies on persons who have died of other diseases than tuberculosis, that slight tuberculous infections of the lungs have cured themselves without treatment.

These facts show that human beings have normally considerable resistance to tuberculosis. When an infection becomes active, something has happened to break down the defenses of the body and allowed the bacilli to get a start. A person's resistance to tuberculosis is not fixed, but is always changing throughout his lifetime. Sometimes it is high, and sometimes low. It is kept at a high level by everything that leads to a normal life—good food, fresh air, sufficient rest, and recreation, in fact, everything that keeps one in good condition. It is diminished by anything which decreases bodily vigor. Among these influences are: other infections, such as measles, whooping cough, and influenza; too frequent child-bearing; overstrain and fatigue; poor living conditions of all kinds; alcoholism and malnutrition.

Malnutrition.—The relation between malnutrition and tuberculosis is particularly close. In Europe the prolonged undernutrition of both adults and children during the World War has resulted in an enormous increase of tuberculosis, which will continue for years to come, because of the poverty and exhaustion following the war. In this country, also, there are large numbers of poorly nourished children, who are possible candidates for tuberculosis. There is a great public health movement under way to improve the condition of these children by means of nutrition clinics, health teaching in schools, and instruction of mothers in food values.

Social Conditions.—Tuberculosis is *closely connected with social conditions* in a community. It is much more frequent among the poor than among the well-to-do, and its prevalence is related to poverty, ignorance, overcrowding, overwork, poor nutrition, alcoholism, and infectious diseases. Low standards of living mean lack of isolation, of rest, sunlight, fresh air, and cleanliness; lack of medical and nursing care; insufficient food; and, in fact, all the conditions that tend to spread the infection and prevent the patients' recovery. The death rate from tuberculosis in any community indicates clearly what are the social conditions. If they are bad, the death rate from tuberculosis is high; while if the population is in good circumstances, well fed, and not overcrowded or overworked, the death rate from tuberculosis is low.

The **early symptoms** of tuberculosis of the lungs are loss of weight, tired feeling, slight fever in the afternoon, loss of appetite, and a hacking cough with perhaps a little sputum. Sometimes, also, tuberculosis starts like an ordinary cold, which, however, does not get well. Any of these suspicious symptoms should send a person to the doctor at once for a thorough examination. A "rundown" condition from any cause is a danger signal and demands a thorough physical examination and treatment for building up the strength. *Early diagnosis and treatment are of the utmost importance for the cure of tuberculosis.* The earlier the diagnosis is made the better is the prospect that the disease will be stopped. In a general way, more than 80 per cent of very early cases can be arrested, 25 per cent of the moderately advanced, and 10 per cent of the far advanced. Many cases come under treatment too late.

There are two main ways of preventing active tuberculosis. The first is to prevent the infection of children; we shall discuss this later. The second is to keep the resistance of infected persons at such a high level that the bacilli present in the body cannot spread and multiply and produce the disease. This is just as truly prevention of tuberculosis as is the protection of children. We have already mentioned some of the influences which may cause an infected person to break down with the disease. Some of the measures which will help to prevent such a breakdown are: diminishing the number of preventable infections, particularly those of the respiratory tract; better care during convalescence from various diseases, and during child-bearing; avoiding overfatigue and overstrain, both physical and mental. All efforts which improve the conditions under which people live and work have their influence in diminishing tuberculosis.

The discovery that childhood is the time when many adult cases of tuberculosis have received their infection shows us where to concentrate our efforts for preventing the disease with the greatest hope of success. The feature of tuberculosis prevention at the present time is the increasing emphasis placed on the child. *The children who are today being exposed to the disease will form the majority of the consumptives fifteen or twenty years from now.* Real protection of children in a family in which there is a case of tuberculosis is impossible. There will be infection in spite of all attempts to prevent it. Either the patient should go to an institution, or the children should live elsewhere. The welfare of the children must be the first consideration, for it is only by protecting them that the ravages of the disease in the family can be stopped in the present generation.

The most frequent form of tuberculosis in childhood (from five to twelve years) is infection of the lymph glands of the neck and chest. This is the time of life when the disease can be most readily overcome, if it is diagnosed and proper treatment started. The symptoms of tuberculosis in children are failure to gain weight, loss of energy and appetite, and increase in the afternoon temperature from ½ to 1 degree, and occasional attacks of fever, called "colds." *All children who are delicate, easily fatigued, and not gaining weight should have a thorough medical examination. Every child who has been exposed to tuberculosis in the home should be under medical supervision for many years.* The hope for the final victory over tuberculosis lies to a great extent in the prevention of the heavy infection of children, and such good care of those who have been infected that the disease will never develop.

Cases of tuberculosis are classified as "open" or "closed." An open case is one who is casting off bacilli in the sputum or other excretion; a closed case is one who is not throwing off the bacilli, and is, therefore, not a danger to others. An open case may heal and become closed; a closed case may start up again and become open.

Care of Excretions.—As with any other infectious disease, the proper *care of the excretions* by which the disease is spread must be rigidly carried out. Every consumptive must be taught to live so that he will not be a danger to others. He need not be isolated like a case of acute infectious disease, if he is careful and cleanly; but he must take proper precautions to protect others. He should use paper sputum cups and gauze or paper handkerchiefs. When away from home he should carry a pocket sputum flask. He should have a separate set of dishes, which should be boiled after use. He should sleep alone. He should take special pains not to soil his hands with sputum, and he should avoid contact with children.

Every tuberculous patient must be trained to avoid exposing others, and he must also be taught how to live hygienically so as to help along his own recovery. This teaching is the most important function of the sanatorium, and it can also be carried out successfully at home. The training, care, and encouragement of the patient in his own home is largely given over to the nurse, and forms one of the most important and hopeful branches of public health nursing.

All civilized countries are today carrying on a **public health campaign against tuberculosis.** Here we can mention only the chief agencies that are being used in the United States.

1. The first is the *tuberculosis clinic,* which examines patients, makes the diagnosis, treats those patients who must remain in their own homes, and supervises patients who have returned from sanatoria. Attached to the clinic are **public health nurses,** who visit all patients under the care of the clinic, make arrangements for treatment at home, and instruct the patients and their families as to the necessary precautions. Tuberculosis

nursing was one of the earliest forms of public health nursing to be developed.

2. The *sanatorium* is for the early and more hopeful cases of tuberculosis. Its most important function is training the patients, teaching them the precautions they must take to avoid infecting others, and also right habits of living, so that they may keep the gains they make under treatment.

3. The *tuberculosis hospital* is for the care of advanced cases. It is of great value in the isolation of these patients who are the greatest sources of infection on account of the large amount of sputum which they excrete.

4. The *preventorium* is for children who have been exposed to the disease and are undernourished but have not yet developed active symptoms. Its object is to prevent the development of tuberculosis by building up the children's resistance by means of food, fresh air, rest, and the correction of physical defects.

The outlook for the final victory over tuberculosis is encouraging. In the United States there has been a marked and steady decline in the death rate during the last hundred years, and this is still going on. Between 1900 and 1920 the death rate was almost cut in half. Many causes have contributed to the decrease in tuberculosis, some directly, some indirectly. The antituberculosis campaign which has been carried on continuously in this country for the last forty years, has been of immense importance; but even more valuable has been the change which has come over the mode of life of the American people in the last generation—more hygienic personal habits, more outdoor life and recreation, a more rational diet and consequently better nutrition, more sensible ways of bringing up children, and a general interest in matters of health. There has also been an improvement in social and industrial conditions. People live and work in more healthful surroundings, there is less poverty, and the general average of health, physical comfort, and wholesome interests has increased. All these various influences tend to prevent breakdowns from tuberculosis.

CHAPTER XXVI

THE PREVENTION OF TYPHOID AND PARATYPHOID FEVER AND DYSENTERY

The reduction in the number of cases of typhoid fever in the United States during the last seventeen years has been one of the great triumphs of preventive medicine. For a long time typhoid stood fourth among the causes of death, following tuberculosis, pneumonia, and cancer. It has now been reduced to a much lower place. In 1910 over 25,000 persons died of typhoid fever in the United States. In 1927 there were about 10,000 deaths. Typhoid most frequently attacks young people. One-half of all cases occur between the ages of fifteen and twenty-five, and about one case in ten results fatally.

The disease is more frequent in the country than in cities. This is because city water supplies are better; cities are sewered; milk supplies are generally pasteurized; typhoid patients are usually taken care of in hospitals, so that there is less opportunity for the infection of others; and in cities carriers are more easily discovered and controlled.

The measures for the prevention of typhoid and paratyphoid fever are:

(1) those concerned with the patient and the disinfection of his excretions;

(2) the control of carriers;

(3) the sanitary control by the public health authorities of water and milk supplies, sewage, and food handlers;

(4) protection against the disease by the use of antityphoid and paratyphoid vaccines;

(5) the measures that each person should take for his own protection.

These will be considered in turn. It may be pointed out that all rules outlined for the prevention of typhoid fever apply also to paratyphoid fever and dysentery.

1. **Measures Concerned with the Patient.**—The place where typhoid, paratyphoid and dysentery bacilli can be dealt with most effectively is at the bedside as they come from the patient and before they are scattered. This is preventing the diseases at their source. The disinfection of the excretions is the special duty of the nurse, who has a great responsibility not only for the welfare of the individual patient, but for the protection of the community. The feces and urine must be disinfected, as well as everything that could possibly be contaminated with them; as bed linen, clothing, wash water, etc. It is advisable for the nurse to wear rubber gloves and a rubber apron when waiting on patients with these diseases, or disposing of the excretions. The patient's dishes should be boiled.

The patient must be isolated as a case of infectious disease; no visitors should be allowed in the sickroom. The milkman is notified, as a rule, by the health department. The person who does the nursing should not prepare food for any one else, or even for herself. It is simply impossible to keep up any kind of real isolation at home if one person must do both the nursing and the cooking. Typhoid and dysentery cases should, if possible, be treated in hospitals, where the chances of contact infection are less and the conveniences for disinfection better.

The greatest danger of infection is not, however, from the *known* typhoid, paratyphoid, or dysentery patient, but in the early stages before the diagnosis has been made, and in the cases which are so mild that they are never diagnosed. *Every patient having any intestinal disturbance associated with fever should be put on typhoid precautions until a diagnosis can be made.* This measure would prevent the spreading of dysentery and paratyphoid fevers, as well as of typhoid. *It is better to isolate unnecessarily than too late.*

No typhoid, paratyphoid or dysentery convalescent should be taken out of isolation until three consecutive specimens of feces and urine, taken at intervals of six days, have been found negative for the causative bacilli. The first specimens should be sent when the temperature is nearing normal. Even with repeated examinations under the most favorable conditions some carriers will be missed. (See Chapter on Collection of Specimens.)

2. **Control of Carriers.**—The control of carriers is the most difficult part of the antityphoid program. The greater number of the carriers discovered are those who have infected other persons through food or milk. They are most often cooks, housewives, boarding-house keepers, nurses, or milk handlers. A carrier who has nothing to do with the handling of food or milk is not so likely to be a danger to other persons. The most important point in regard to carriers is their *occupation*. *Health departments in many states keep proved carriers under supervision.* The co-operation of the carrier is

enlisted, and definite rules and restrictions are laid down, the most important of which is that the carrier shall not engage in any occupation requiring the handling of food and milk; that the feces shall be disinfected and also the hands after using the toilet. The health authorities keep in touch with carriers by means of visits and reports.

3. **Sanitary Measures.**—The frequency of intestinal infection in any community depends to a large extent on sanitary conditions; that is, those relating to water and milk supplies and the disposal of feces. *The prevalence of typhoid shows what are the sanitary conditions in a community, as the frequency of tuberculosis indicates the social conditions.* The intestinal infections, typhoid, paratyphoid, and dysentery, offer a marked contrast to the group of diseases carried by the secretions from the mouth, as pneumonia, whooping-cough, and measles. These latter are as frequent in clean communities as in dirty, since sanitary measures have no effect on their prevalence.

The reduction of typhoid in cities in the last twenty-five years has been due in great part to providing clean water supplies and pasteurizing milk. Most of the typhoid in large cities today comes from contact with cases or from carriers.

A **pure water supply** is the first sanitary necessity for getting rid of typhoid, for if a water supply is polluted with sewage the population will frequently get doses of typhoid bacilli. If wells are used, they should be at a long distance from outhouses, should be dug deep, the sides tightly cemented to keep surface water out, and the tops covered. Laboratory examination of the water should be made each spring and fall at least.

The second necessity is the *proper disposal of sewage* to prevent it from getting into water supplies. In cities and towns where there is a sewage system, all the sewage can be treated at one plant by scientific methods and made entirely harmless and inoffensive. If a community is too small to afford a sewage system, it can provide sanitary privies, which will prevent contamination of wells and the spread of bacteria by flies and animals. Even a very simple type of privy can be made to fulfil these conditions. The health departments of a number of states have, in recent years, been carrying on an energetic campaign for sanitary privies, with the result that there has been a marked reduction in rural typhoid.

The **pasteurization of milk** is essential for reducing typhoid and other diseases. This has already been discussed. Milk supplies in the large cities, where practically all the milk is pasteurized, are only rarely the cause of typhoid. In smaller cities, on the other hand, pasteurization is less general, and in small towns all over the country, very little milk is pasteurized. Under these conditions infected milk still accounts for considerable typhoid.

Many cities require an **examination of food handlers** in public eating places, in order to exclude persons having communicable diseases.

4. **Individual Prevention.**—For one's own individual protection certain precautions should be taken. If one suspects that the water supply is polluted, drinking-water should be boiled. The common household water-filters are untrustworthy, and so are some of the bottled waters which are popular in cities where the water supply is doubtful. Campers, picnickers, and

vacationists should be careful about their drinking-water. Milk should be pasteurized in the home unless one is sure that it has been produced and distributed under clean conditions. It is better to avoid taking milk in public eating places unless it is served in the original bottle and has been pasteurized. Finally, every one should be protected by *inoculation*. (See Chapter XV.)

Antityphoid and Paratyphoid Inoculation.—*Wherever antityphoid and paratyphoid inoculation has been carried out among groups of people, as in the Army and Navy, institutions, and nurses' training schools, it has practically eliminated typhoid.* The persons for whom antityphoid immunization is most necessary are:

First, those especially exposed to the disease on account of their work. This includes doctors, nurses, medical students, attendants, orderlies, and hospital employees. *There is no excuse for medical and nursing schools not requiring inoculation of their students, or for doctors and nurses not keeping up their immunity.* Yet in Massachusetts, in 1926, about thirty nurses in a certain hospital had typhoid, and of these one died. None of them had been inoculated against typhoid. Statistics from a number of large hospitals show that typhoid was formerly from two to eight times more frequent among those who come into close contact with patients, that is, doctors, nurses, and orderlies, than among the general population; and also that they are more likely to have the disease in a severe form, with more complications and a higher mortality, because they get the bacilli absolutely fresh from the patient in which condition *all* germs are more virulent.

Second, all members of families in which there is a case of typhoid should be protected at once. *No one* *who is not immunized to the disease should be allowed to nurse a typhoid patient.*

Third, groups of persons who live in close contact. This includes inmates of state hospitals, prisons, institutions for children and young people, residential schools, army camps, ships, and colleges. Immunization of all persons connected with state hospitals is particularly important. Several outbreaks in such institutions have been traced to carrier-patients who worked in the kitchens or dining rooms. An epidemic which occurred in a large maternity hospital a few years ago was caused by the cook, who was a carrier.

Fourth, all persons who travel should be inoculated, as they must often partake of food and drink of doubtful origin. This group includes vacationists, traveling salesmen, missionaries, and persons who are going to foreign countries.

Fifth, the general public should be immunized when there is an epidemic or in places where typhoid is prevalent. *The more persons who are immunized against any disease, the sooner will it disappear.* This applies not only to typhoid but to diphtheria and smallpox and, in fact, to any disease against which it is possible to protect.

The value of antityphoid and paratyphoid immunization has been known for more than twenty years. It is offered free by state and city health departments. It has practically eliminated the disease in the Army and Navy in time of peace, and in institutions in which every person has been treated. The inconvenience is trifling in comparison with the protection afforded. Nurses cannot afford, for their own sake, to neglect this measure for their protection. In addition it is their duty, as persons professionally interested in preventive medicine, to do all in their power to popularize the use of antityphoid immunization.

Antityphoid vaccination does not take the place of other measures against typhoid, but is an addition to them. It will be impossible for some time to come to get rid entirely of sources of typhoid infection, particularly of carriers, and antityphoid immunization protects against infection which we cannot avoid. It is customary to include paratyphoid A and B in the same injections with typhoid vaccine.

Prevention of Infant Dysentery.—The methods of preventing the spread of *adult* dysentery are in general the same as for typhoid and paratyphoid fever. *The prevention of infant diarrhea*, however, depends first on encouraging breast feeding; second, on teaching mothers correct methods of caring for babies and of preparing their food; and third, on the general improvement of milk supplies and pasteurization or boiling of all milk. The breast-fed baby not only gets milk which is especially suited to its needs, but it gets it in a sterile condition. When a baby is artificially fed the milk should be pasteurized or boiled and *protected from flies.* Nursing bottles and nipples should be sterilized by boiling before each use; the feedings should be prepared by a person with clean hands, and the bottle, after it is prepared, kept away from flies and dirt. Babies should be kept away from any one having an intestinal disturbance. *A person who is caring for a child with summer diarrhea should not prepare food for other children or for adults.* The baby's crib and carriage should be screened during the fly season. The diapers of infants suffering from diarrhea should be sterilized at once. Old linen, which can be burned when it is soiled, should be used if possible.

Dysentery is liable to spread in children's hospitals and infant asylums, so that such patients should be isolated with strict precautions.

The baby welfare clinics have also been a strong factor in diminishing dysentery in infants. The public health nurses connected with these clinics visit the homes and teach the mothers correct methods of preparing the baby's food and the general care of the child.

CHAPTER XXVII

PREVENTION OF DIPHTHERIA

Within the past few years a practicable method of giving permanent protection against diphtheria has been devised. *Immunity to diphtheria depends on the presence of antitoxin in the blood.* As long as a person has antitoxin he will not develop diphtheria, even though the bacillus may lodge in his throat. A large proportion of adults and a small proportion of children have antitoxin naturally in their blood, and are therefore immune to the disease, even though exposed to it. This is called *natural immunity* (p. 75).

Artificial Immunization against Diphtheria.—Now it is possible to stimulate the human body artificially to produce antitoxin by the injection of toxin. The method consists in the injection of a very small amount of diphtheria toxin mixed with enough antitoxin so that the toxin is not dangerous. The antitoxin has nothing to do with the production of the immunity, but it prevents the toxin from being irritating. The toxin stimulates the body to produce antitoxin *over a long period of time.* Three 1 cc. doses of the toxin-antitoxin mixture are given subcutaneously at intervals of one week (Fig. 38, d). *The immunity appears slowly* in two to three months, but once established *it seems to be lasting.* The procedure is absolutely harmless. Infants have no symptoms from it, but in adults the reactions are sometimes similar to those following antityphoid inoculations. The procedure is spoken of as *toxin-antitoxin treatment*, or "T-A-T" for short. *The immunity produced by it is active* (*slowly developing and permanent*), *in contrast to the passive immunity given by antitoxin* (*immediate but transient*) (p. 79).

The Schick Test.—Not only is there a method of giving lasting resistance to diphtheria, but there is also a test for determining whether a person is susceptible to diphtheria; that is, whether he would develop the disease if exposed. This is called the Schick test after the Viennese physician who first made practical use of it. It depends on the fact stated above that some persons have antitoxin naturally in their blood. It depends on exactly the same principle which underlies the Dick test in scarlet fever, and is done in the same way and the same sort of reaction occurs. The test is performed by injecting into the skin an extremely small amount of diphtheria toxin (Fig. 38, b). If the person has no antitoxin in his blood, a small red area appears at the place of injection within twenty-four hours (Fig. 38, c). This is caused by the irritating effect of the toxin on the cells of the skin, which are not protected by antitoxin. It is a positive reaction and means that the person is susceptible to diphtheria. If he does have antitoxin in his blood, the antitoxin counteracts the toxin injected, and the skin remains normal. This is a negative reaction and shows that the person is immune to diphtheria. The test is harmless, painless, and leaves no scar.

Toxin-antitoxin Immunization of Children.—With the combined use of toxin-antitoxin injections and the Schick test it is now practicable to protect the entire child population against diphtheria. Extensive campaigns are now being carried on in the public schools of cities throughout the country, with the object of immunizing every pupil who has been shown by the Schick test to be susceptible. The treatment has passed the experimental stage and, in most cities, has become a regular part of the school medical work. In New York City alone over a million children have been immunized with no ill effects. In this city the number of deaths from diphtheria has dropped from 1245 in 1918 to 476 in 1926. Immunization was started in New York in 1921.

The protection of children of preschool age is even more pressing than that of the school population, because the frequency of diphtheria is greater among them, and a large proportion of the deaths occur at that period. The protection of the preschool group is now being undertaken through "well-baby" stations, playgrounds, day nurseries, and special clinics. If all children could be immunized at one year of age, there would be only a small fraction of the amount of diphtheria that there is at present. Health departments try to inoculate in summer all children who are to enter school in the fall.

Immunization of Nurses.—*It is scarcely necessary to say that every nurse should be protected at the beginning of her training, whether or not the course includes the care of contagious diseases.* Of 380 nurses tested in a number of Massachusetts hospitals, 52.8 per cent gave a positive Schick reaction.

Deaths from Diphtheria.—*Diphtheria is today an absolutely preventable disease,* just as smallpox is; yet people still die from diphtheria, chiefly because the diagnosis is not made early and antitoxin given. It is the most frequently fatal disease among children from one to three years of age. At present there are between 90.000 and 100,000 cases in the United States each year, and about one patient in every ten dies. The chief cause for this great and unnecessary number of fatal cases is that the doctor is not called until the child's condition becomes grave, and then it is too late for any amount of antitoxin to cure the disease. The parents of some of these children are simply ignorant; others belong to cults which do not believe in medical treatment. *Early diagnosis and prompt administration of antitoxin would prevent nearly all deaths from diphtheria.*

The fundamental way to meet the diphtheria problem is, however, to make the population permanently immune, instead of waiting for the disease to develop. By immunizing the children as fast as possible, a protected population will gradually grow up, just as we now have in some States a population protected by vaccination against smallpox. A good beginning has been made on immunizing children, and results are apparent in a reduction of the death-rate. The outlook is very hopeful. Diphtheria can be and will be eliminated.

CHAPTER XXVIII

THE PREVENTION OF MEASLES

The prevention of measles is a difficult problem, because the disease is most infectious during the early stages, when the symptoms are those of a cold and before a suspicion of measles has been aroused. During this period the child is usually running about or is in school, diligently spreading the infection. When a case of measles has appeared in a school or an institution, the greatest hope of limiting the spread of the disease lies in *isolating all persons having symptoms of a cold*, or known to have been in contact with the patient while he or she had the early or later symptoms. Although it is very difficult to diminish the number of cases, a great deal can be done to decrease the number of deaths from the disease:

First, by preventing the complications by means of good nursing, and

Second, by protecting very young children from infection.

Convalescent serum is used for the prevention of measles. The best time for bleeding convalescents is from the sixth to the tenth day after the temperature has reached normal. Blood-serum from persons who have had the disease several months or even several years previously has also been used with success. If the serum from a convalescent is injected into an exposed person within the first four or five days after exposure to measles, it will protect the child for about a month. The immunity is passive and consequently it soon wears off. If the serum is injected in small doses after the fifth day of exposure, it does not prevent the disease but modifies its course, making it very mild. This mild attack, however, probably gives permanent protection. Both the complete passive immunity and the modified attack have their fields of usefulness. If measles appears in a hospital or a children's institution, the first indication is to stop it by completely protecting the children. Very young and feeble children, and those suffering from rickets, whooping-cough, or other diseases, should also be completely protected if they have been exposed to the disease. In the case, however, of normal robust children over five years old, it is usually more desirable to obtain a modified and mild form of the disease which will give permanent immunity, rather than to protect the child absolutely for a short period.

The Health Department of New York City (and possibly of other cities) keeps the convalescent serum on hand for the use of physicians. The use of the serum is now a practical procedure which awaits a wider development. It should have great influence in reducing the death-rate from measles.

CHAPTER XXIX

THE PREVENTION OF THE VENEREAL DISEASES

There are no exact statistics on the prevalence of syphilis and gonorrhea in the United States. The most accurate ideas which we have at present are based on examinations of different groups in the population. Their frequency among young men of all classes is apparent from the figures for the recruits received in the army camps during the World War. From September to November, 1918, of 165,835 white men examined, 3.55 per cent were found to be infected, and of 40,094 colored men, 20.7 per cent.

Syphilis is much more wide-spread in the community than is generally supposed. Physicians who have studied the question most thoroughly consider it a safe estimate to say that from 8 to 10 per cent of the population of large cities have been infected with the disease. It has been estimated that there are between six and ten million syphilitics in this country. Syphilis and tuberculosis rank together as the greatest causes of disability and death in the colored race.

As for gonorrhea it would be a hopeless task to try to determine the frequency of this disease among the general population, as so many cases are mild and are treated with indifference.

Death-rate.—The total number of deaths from syphilis is unknown because the disease rarely kills immediately, and most of the deaths for which it is really responsible are reported as due to other diseases, chiefly those of the heart, arteries, and nervous system. Nevertheless, in 1927 there were reported in the United States a large number of deaths from syphilis, locomotor ataxia, and paresis, combined. Even this incomplete account ranks syphilis high among the causes of death, and if the true figures could be collected, syphilis would probably be classed among the more frequent causes of death, along with tuberculosis and pneumonia. Probably almost half of all syphilitics die from some of the late results of their infection.

Fig. 53.—In some cities all persons charged with committing sex offenses are examined by physicians for venereal disease, and if found to be infected, are isolated and treatment is made compulsory. The photograph shows the male companion of a street-walker (From "Two Years Fighting Venereal Diseases," Published by U. S. P. H. S.).

Prostitution is of course a means of keeping venereal diseases alive in a community and of spreading it to other communities. One infected delinquent or immoral person may be the means of infecting, directly

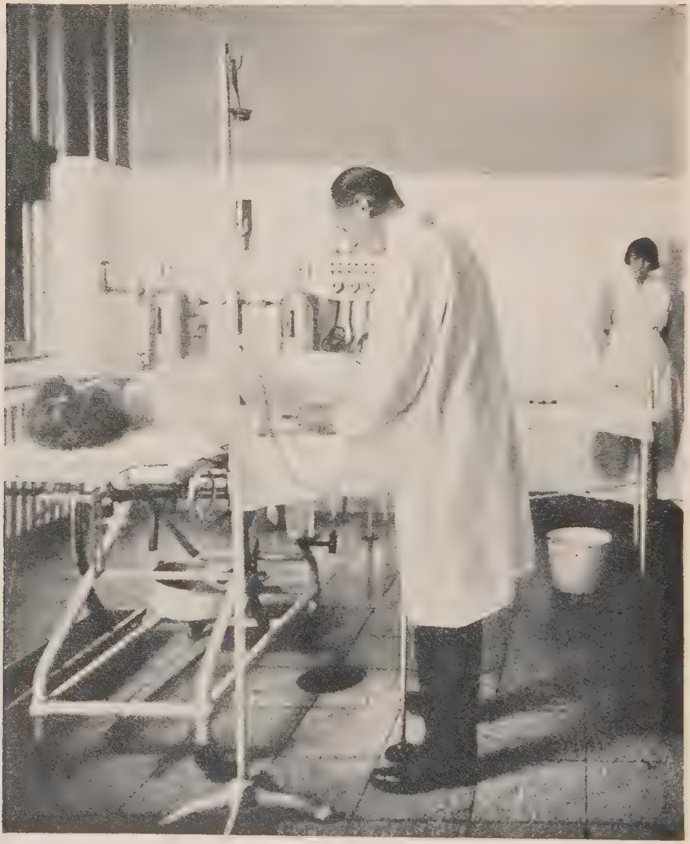


Fig. 54.—The venereal disease clinic in operation with clinician and nurse administering arsphenamine (salvarsan) for syphilis (From "Two Years Fighting Venereal Diseases," Published by U. S. P. H. S.).

or indirectly, dozens of other people. Most states and cities now have legislated against prostitution and men or women convicted of delinquency may be compelled to receive treatment and actually confined to prisons or suitable institutions (see Figs. 53 and 54).

Syphilis as a Family Disease.—Syphilis is a family disease quite as much as tuberculosis. If the husband has the disease, it is quite likely that the wife and children have also been infected. The effect of syphilis on the family is demonstrated in the study by H. C. and M. H. Solomon in Boston. At least one-fifth of the families of the patients examined were found to have one or more syphilitic members in addition to the original patient. In more than one-half of the marriages there had been either no children or miscarriages and syphilitic children. The members of the family usually have no idea that anything is wrong with them and consequently the disease is often overlooked until irreparable damage has been done.

If one person in a family is found to have syphilis, it is of the greatest importance to have the other members examined. By getting the infected members under treatment early the late results of the disease may be avoided.

The Present Attitude toward Venereal Diseases.—The World War brought about a new attitude toward venereal disease. Up to this time the problem had never been squarely faced because it was not considered suitable for discussion. The result of this attitude was that practically nothing had been done to control syphilis and gonorrhea, and in the public mind the whole subject was surrounded by a haze of mystery and horror. At the time of the war the seriousness of the situation was forced on both military and civil authorities, and a campaign against venereal disease was begun. This has been continued since the war and results are now apparent. Frank discussion of the subject and education of the public are slowly overcoming the hypocrisy and false modesty with which these diseases have been surrounded, and a beginning was made on a program for their control some time ago. The public health control of syphilis and gonorrhea is less efficient than in the case of other infectious diseases. This is both because it is newer, and because the problem of the venereal diseases is bound up with social, psychological and moral questions in a way that other infectious diseases are not.

The Prevention of Venereal Diseases.—This is one of the most urgent public health questions. Syphilis and gonorrhea should be dealt with in the same way as are other communicable diseases. The immediate problem is to *prevent the spread of the infection.* This is done by precautions taken by the patient and by making him noncontagious as soon as possible through treatment.

Unfortunately, persons in the most infectious stages of gonorrhea and syphilis are usually not incapacitated. They continue at their daily work, and hence are more liable to spread the disease than are persons who are confined to bed and thus partially isolated. The best place for these patients during the acute stages would be a hospital, but under present conditions treatment in hospitals is impracticable except in special cases.

During the infectious period the patient should keep himself and the things which he uses away from others. This means a separate bed, separate eating utensils (for syphilitics), towels, wash cloths, etc., and sterilization of articles contaminated by the secretions, in the same way as in any infectious disease.

The syphilitic can be made noninfectious in the ordinary relations of social and business life in a short time by *treatment with arsphenamin.* Three to five injections will go far toward making the patient noninfectious, so that he will no longer be a danger except to those in the closest contact, although he must still continue to observe precautions. This is one of the most practical ways of diminishing syphilis. Most state, and many city, health departments now conduct clinics where treatment for venereal disease may be obtained free of charge. Many hospitals coöperate in the campaign.

Treatment begun early and continued faithfully tends to prevent the later symptoms, such as diseases of the heart, arteries, and nervous system. Syphilis is probably not an incurable disease if treated early and thoroughly. Treatment begun at a later period will in many instances prevent the advance of the disease, although it is too late for a cure.

Finding as many of the infected persons as possible and getting them under treatment is a most important part of the program for the prevention of venereal diseases. A Wassermann or Kahn test should be made on every hospital, dispensary and institution patient, because unrecognized and late cases of syphilis are found in every large group of general population. Routine use of the test picks out those cases that would otherwise be overlooked.

Sufficient hospital and dispensary accommodations for the treatment of syphilis and gonorrhea are also necessary if the damage which these diseases do is to be diminished. At present both hospital and dispensary provisions for these diseases are inadequate. Practically all hospitals refuse to take syphilis and gonorrhea in their early and curable stages, although they are perfectly willing to care for the complications and the late and incurable conditions. The venereal disease clinic, as mentioned above, serves as a center for the diagnosis, treatment, and instruction of the patient and his family. It is also the starting point for co-operation with the medical and social agencies which are necessary for their restoration to health and their social reconstruction. In 1927, there were given over two million free treatments for venereal disease and nearly one million free blood examinations were done by various state laboratories.

The *treatment and prevention of congenital syphilis* is one of the most important parts of the program against syphilis. It is a field in which vigorous preventive work will accomplish much. Every pregnant woman should have a Wassermann or Kahn test, and all those with a positive reaction should have thorough treatment. The earlier in pregnancy the mother comes under treatment, the better the chance that the child will escape injury.

The children of parents known to be syphilitic should be kept under medical observation, even though they show no signs or symptoms of the disease. The situation is similar to that of children in whose families tuberculosis exists. In infancy congenital syphilis yields to treatment much more readily than in later childhood. If the disease were always well treated in infancy, the number of children showing the late and irreparable consequences of congenital syphilis would be much reduced.

The educational, legal, and social methods of attack on venereal diseases rank in importance with the medical, but it is not within the province of this book to do more than mention them.

The educational campaign has been carried on vigorously during and since the late war by means of literature, notices, talks, lectures, and motion pictures. The aim has been to acquaint the public with the method of spread of the venereal diseases and their results, using accurate, clear, and simple language, and presenting the subject in an unsensational and unsentimental way. The gradual sex teaching given to children and young people in the home and school would be included here.

The legal attack centers around breaking up prostitution as a business, and the protection of young girls and feebleminded women.

The social methods of combating venereal diseases are as valuable for future results as are the medical methods in dealing with existing cases and preventing the spread of infection. These include, first, home training in character and ideals, for poor home training is the greatest cause, except mental defect, of sex delinquencies among young people. Recreational, intellectual, and other interest, which compete with those of sex, are important in raising the level of sex conduct, in both young people and adults.

The adoption, through the force of public opinion, of the single standard of sex conduct for both men and women will, in the long run, do more than anything else to suppress venereal diseases. Public opinion and education are slowly acting forces, but they get at the root of the problem, and their gains are permanent. The immediate duty of medicine and nursing is to deal with the existing cases and to prevent the spread of infection; but at the same time they must be working for long-distance results.

CHAPTER XXX

THE PREVENTION OF MALARIA

Malaria is entirely preventable. The disease is attacked along three lines; first, *the extermination of mosquitoes;* second, the preventing of mosquitoes from getting at persons, *by the use of screens;* and third, the *destruction of the parasites in human beings* through the use of quinin.

Mosquitoes.—Malaria prevails where mosquitoes find congenial conditions of life; that is, in lowlands, and near swamps and bodies of stagnant water (see Fig. 55). It is largely a rural disease. The name malaria means literally, "bad air," and was given to the disease because it used to be thought that there was some unhealthful condition of the air in marshes and lowlands which caused the disease. We now know that malaria is associated with low-lying places because mosquitoes live there.

The destruction of the breeding places and eggs of mosquitoes is the most permanent and thorough way of fighting malaria. Breeding places are destroyed by draining swamps, filling in pools, and clearing the edges of ditches and streams. The developing eggs are killed by spraying coal oil on the surface of the water. Bodies of water in which mosquitoes breed may be stocked with minnows which eat the eggs. This is an excellent method where possible. Large swamps and bodies of shallow, stagnant water have been successfully sprayed with oil from aeroplanes.

Screening is of much value if it is carefully and intelligently done. Malaria patients must of course be protected from mosquitoes to prevent spreading their infection further.

Malaria Carriers.—A considerable proportion of persons in a region where there is much malaria harbor the parasites in their blood without having symptoms of the disease. Some of these people have had attacks in the past, but many are unaware of ever having had the disease. The parasites may remain alive in the spleen and other organs for years. About 10 per cent of healthy adults in malarious districts and a much larger proportion of children carry the parasites. It

FIG. 55.—Where mosquitoes breed by millions (Howard).

is apparent that mosquitoes biting these people will become infected and pass the organisms along to healthy persons. These carriers are much more numerous than the actual cases of malaria, and they are one of the most, if not the most, important means of keeping the disease alive. If the blood of all infected persons in a community could be freed of parasites through the use of quinin, malaria would disappear, even though Anopheles mosquitoes were still present. On the other hand, if the mosquitoes were exterminated, no new persons would become infected, no matter how many carriers there might be.

Quinin has a specific action on the malarial parasite just as arsphenamin has on the Spirochæta pallida. After an acute attack it is of the greatest importance that quinin should be continued in sufficient doses for some time, in order to kill all the parasites and thus prevent the patient from developing into a carrier. A course of quinin treatment is also necessary for disinfecting carriers. Persons living in malarious regions take quinin regularly to prevent the development of the disease.

Malaria as a Social Problem.—If a person has once been infected, it is quite difficult to free him completely from malarial parasites. Unless quinin treatment is pushed vigorously during the attack and kept up for some time after recovery, the disease will continue to break out at intervals. Persons having chronic malaria are semi-invalids; they are weak, anemic, and listless, unable to work much, and without ambition. Child carriers remain undeveloped and backward. *The disease is thus of great social and industrial importance.* Where many persons are affected, the effect is apparent in the community life. Such communities are of low grade, shiftless, poverty-stricken, and of small working capacity. In regions where malaria prevails extensively, it is a great obstacle to social progress and industrial efficiency, and its suppression is the most important sanitary work that can be undertaken. Regions in which malaria has been controlled show a marked improvement socially and industrially.

Permanent success in controlling malaria will follow a combined attack on the mosquito and on the parasite in human beings. The suppression of malaria is largely a financial problem. Any community can rid itself of the disease if it can and will spend enough to destroy the breeding places of the mosquito and to find and disinfect human carriers.

CHAPTER XXXI

THE ACUTE COMMUNICABLE DISEASES AS A PUBLIC HEALTH PROBLEM

These diseases (mumps, measles, chickenpox, whooping cough, diphtheria, scarlet fever, infantile paralysis, etc.) are important for both their immediate and their later effects. Infections, chief among which are the contagious diseases noted above, are the most frequent cause of death in children between two and five years. Even in children who recover completely, nutrition and growth are interfered with for some time. The weakened condition after an infectious disease, in either a child or an adult, may allow tuberculosis to get a start. The *consequences* of the contagious diseases are often of greater importance than the diseases themselves, for the vital organs may be permanently damaged by these diseases in ways which seriously handicap the victim for life. The injury to the kidneys accompanying scarlet fever may be an important cause of nephritis in later life. The heart is damaged in many infectious diseases, especially diphtheria, and this may be the beginning of serious heart disease. Inflammation of the brain occasionally occurs in acute infectious diseases and may result in epilepsy or mental defect. Scarlet fever as a cause of deafness has been mentioned. These illustrations show that the prevention of the contagious diseases is one of the most important health problems.

Social Conditions Which Favor Infection.—We see the working of these most strikingly illustrated in the conditions of life of tenement-house dwellers. There is, in the first place, poverty, which means insufficient food and clothing, often long hours of work under unhygienic conditions, with fatigue and exposure. Even more important is overcrowding, which necessitates close personal association, with every opportunity for the spread of infection by contact. Where a large family lives in two rooms and takes boarders besides, where children sleep three or more in a bed, all wash with the same cloth and eat from the same dish, where all families in the tenement house use the same toilet, the transmission of germs can scarcely be avoided. Bathing is infrequent, and there are all sorts of uncleanly and unhygienic habits. Quite as important also are the lack of intelligence, the ignorance and superstition which hinder the adoption of modern ideas of hygiene and the carrying out of measures to prevent the spread of infections. These conditions are not by any means limited to the slums; there is poverty, ignorance, and even overcrowding in the country quite as bad as in the city. Wherever they are found, however, they all combine to favor the spread of infection. Overcrowding in schools, institutions and homes, also promotes the spread of infectious diseases.

Even in the beginning of her ward work, the nurse who takes a personal interest in her patients will gradually come to see the influence of social conditions on disease. She will realize them more fully in the out-patient department, especially if there is an opportunity for home visiting. A large part of the work of the public health nurse is concerned with improving the home conditions which tend to spread disease and with teaching the simple rules of personal hygiene.

There are certain points in regard to *prevention and control* which apply to all infectious diseases. The first is the *necessity of isolation* as soon as the first symptoms of any disease appear. Isolation is frequently begun too late. Every person, especially children, with a cold, a sore throat, or fever should be isolated until the diagnosis can be made. Isolation is even more urgent if a rash is present and in case of mild intestinal disturbances which may be forerunners of more severe disease.

Second, *disinfection* and other precautions must be continued just as conscientiously during convalescence as in the height of the disease.

Third in importance are the *mild missed cases* of any disease. These explain the apparently mysterious origin of many known cases. The missed cases are just as infectious as the severe cases and, in fact, even more dangerous, because the patient comes in contact with more people. Many of these cases are discovered by nurses in various kinds of public health work.

Fourth, the *discovery* and *control of carriers* is of equal importance with the isolation of the sick. This applies particularly to diphtheria among the infectious diseases of childhood, although convalescents can spread scarlet fever, whooping cough and other diseases. Carriers can be detected only by laboratory examination; that is, by isolating the causative organism (when it is known) by means of cultures from the excretion or secretion in which the organisms of the disease would be found.

Quarantine.—In smallpox, measles, mumps, chickenpox, as well as in numerous other diseases, most health departments enforce a more or less strict *isolation or quarantine* of all members of a household where there is, or has been, one of these diseases. Persons from outside, such as postmen, milkmen, etc., should not be allowed inside the house. Quarantine is often inconvenient, but anyone who has any consideration for other people and their children, will abide by the quarantine regulations and neither receive visitors nor go among people during the isolation period. Of course, circumstances alter cases and absolute quarantine is often impossible. But it should be adhered to as strictly as possible.

Sixth is the importance of what may be called the *isolation of the well;* that is, preventing them from coming in contact with an infectious disease. This point deserves attention. It applies particularly to children. In general, the younger the child, the more severe the infectious disease is likely to be. As we have seen, most of the deaths from measles, diphtheria, scarlet fever, and whooping cough occur in young children. It is therefore of the greatest advantage to a child if he can be kept away from all infectious diseases until he is at least five years old.

In the case of adults, also, all unnecessary contact with communicable diseases, even such cases as pneumonia, should be discouraged. This would tend to lessen the number of carriers as well as of actual cases.

The importance of shielding from infections old people, babies, and persons with chronic diseases, has been mentioned. An organism which causes only a mild infection in a vigorous person may give rise to a fatal disease in an old person, an invalid, or a baby.

Lastly, the study of the contagious diseases of childhood has shown the importance of the medical supervision of school children. The schools are important centers for the spread of contagious diseases, and with thorough medical inspection and school nursing they can also be made an effective agency for their control.

APPENDIX

A. THE COLLECTION OF SPECIMENS FOR BACTERIOLOGICAL EXAMINATIONS

The nurse sometimes collects specimens for bacteriological examination, so that it is important for her to know the correct methods. If she does not take the specimen herself, she may make the preparations for it; and in any case she should have an intelligent interest in the procedure.

The value of a specimen may depend entirely on the care with which it is taken. In the first place, poorly taken specimens waste the bacteriologists' time. In the second place, it may be impossible to make any diagnosis on such a specimen, or a wrong diagnosis may be made. If it is worth while to take a specimen at all, it is worth while to take it carefully and correctly.

Labeling.—The first consideration about a specimen is the *labeling.* Each label should have on it *the patient's name, the date, and the place from which the specimen is taken* (throat, cervix, abscess, etc.). If specimens are taken from a number of patients at the same time, each one must be labeled as soon as it is taken. If there is the *faintest suspicion* that two specimens have been mixed, both must be discarded and a new start made. A mix-up in throat cultures or Wassermann tubes might have serious consequences.

Specimens should be sent to the laboratory at the *earliest possible moment.* This prevents the specimen from drying, bacteria from dying off, and makes possible an earlier report, and is a convenience to the bacteriologist in planning his work.

Swabs.—Material for bacteriological examination is often conveniently collected on *swabs*. (See Fig. 37.) These are used for a considerable variety of specimens; for example, throat cultures, pus, smears from the cervix, eyes, ulcers, etc. For use in the operating room, culture-tubes are wrapped in a cotton cover, like other surgical supplies, and autoclaved. The outside of the tube is thus sterile and can be handled by the surgeon at the operating table. The important point in taking a swab culture is to touch the swab *only on the spot from which the culture is desired*, and nowhere else, and to send it *immediately* to the laboratory.

Throat Cultures.—They should be taken only with a clear view of the throat. Material to be examined for diphtheria bacilli should be taken directly from the tonsil, or from any white or inflamed spots in the throat. The same is true of cultures for scarlet fever or other infections of the throat. Cultures from the nasopharynx are made particularly for meningococci (Chapter XIII; Section II) by means of a special swab (Fig. 29). Meningococci, when present, are located high up behind the soft palate.

Sputum.—The specimen must be obtained in the proper way if the examination is to be of value. The sputum collected by patients in the ordinary sputum cup consists to a large extent of material from the mouth and throat, mucus, saliva, and bits of food. To collect a sputum specimen correctly, a sterile container should be obtained from the laboratory. The patient should brush his teeth and rinse the mouth thoroughly with water. The sputum should be collected directly after a cough and sent immediately to the laboratory. Sputum is obtained from infants by swabbing the throat.

Health departments supply outfits for collecting sputum for examination *for tubercle bacilli only.* These consist of wide-mouthed bottles containing a little disinfectant. An antiseptic can be used in this case only because in examining for tubercle bacilli, one does not make a culture, but hunts for them with the microscope in a stained smear made from the sputum. *If a culture is to be made* from sputum or any other material, it is clear that a *disinfectant must not be added.*

Urine.—Specimens of urine for *bacteriological* examination are of value only when they are collected with extreme care. There are immense numbers of bacteria on the skin and mucous membrane of the genitalia, and unless the mouth of the urethra is cleansed thoroughly, the culture is sure to be contaminated. The urine is collected by catheterization, and the usual technic for that must be carried out. The first part of the urine is allowed to run off, in order to wash out any bacteria that may be present in the urethra, and the last cubic centimeters are collected in a *sterile* test-tube. Specimens for *chemical* examination do not have to be sterile.

Feces.—Bacteriological examination of the feces is undertaken usually for typhoid and dysentery bacilli. Carriers of both organisms are found by making cultures from the feces. Stools for bacteriological examination should be *fresh.* If blood or pus is present, it should be selected for the culture.

Blood.—Bacteria are present in the circulating blood in various diseases. In septicemia, streptococci are the organisms most often found. Pneumococci often enter the blood in pneumonia. In typhoid fever, typhoid bacilli are present in the blood in the early stage of the disease. Septicemia is always a serious condition. The diagnosis is made by cultivating the bacteria in the blood. The blood is taken from the large vein at the bend of the elbow. The skin over the vein is prepared as for a surgical operation by painting with iodin. A bandage is wound tightly around the upper arm in order to cause the veins to stand out prominently (Fig. 56). The pressure should be sufficient to close the veins but not the arteries. About 10 cc. of blood is removed with a syringe. The bacte-

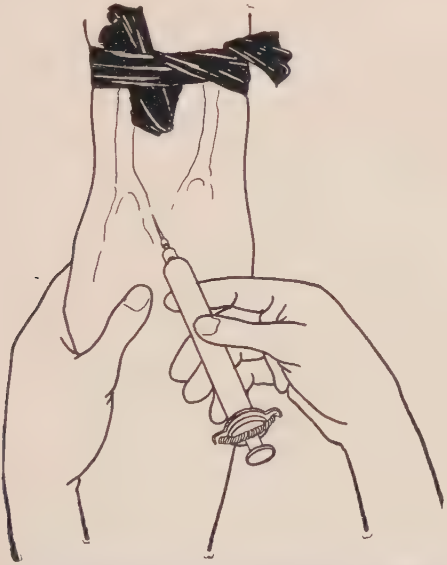


Fig. 56.—Showing method of obtaining blood from a vein for a blood culture (Todd and Sanford, Clinical Diagnosis by Laboratory Methods).

riologist may bring his tubes to the bedside and inoculate them on the spot, before the blood has clotted. If the blood must be carried some distance to the laboratory before it can be inoculated, it is mixed with a sterile solution of sodium citrate which prevents it from clotting. Ox-bile is often used in media for blood cultures in typhoid fever.

Blood for a Wassermann or Widal test is obtained in the same way as for a blood culture, except that, instead of using a syringe, the blood is allowed to flow through a large needle directly into a test-tube. The tube containing the blood should be set upright and *not moved until the blood has clotted.* Health departments furnish, for collecting blood for Wassermann reactions, outfits consisting of a sterile corked test-tube and a sterile needle.

In *infants*, blood for the Wassermann reaction is taken from the longitudinal sinus, a great vein which lies immediately under the anterior fontanel (soft spot on top of head). The blood is withdrawn in a syringe after shaving and cleansing the skin.

A drop or two of blood is often sufficient *for the Widal test* and for making films on slides to be examined with the microscope *for malaria* and other organisms. The lobe of the ear or the tip of the finger may be punctured for this purpose. The finger or ear should be touched with iodine before and after the puncture. The needle should, of course, be sterile.

For the Widal test it is sufficient, unless otherwise directed, to allow a drop to dry on the slide. For microscopic examination the blood must be smeared immediately. For this, the drop is put near one end of the slide. The short edge of a second slide is then held over the drop at an angle. When the edge of the second slide is brought down on the drop, the blood spreads between it and the surface of the first one. Now, with the edge of the tilted slide in contact with the surface of the first one, push the tilted slide away from the drop. A thin, even film of blood will be left behind. Some practice is usually necessary to make a smooth film. (See Fig. 57.)

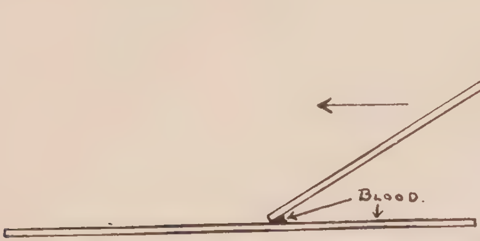


FIG. 57.—Glass slides arranged for making a film of blood for microscopic examination. We are looking at the slides edgewise. The arrow shows how to move the tilted slide.

Fluid from the Peritoneal and Pleural Cavities.—This is either withdrawn in a syringe or allowed to run from the puncture needle directly into sterile test-tubes or centrifuge-tubes. If tuberculosis is suspected, some of the fluid is inoculated into the peritoneum of a guinea pig.

Cerebrospinal Fluid.—This is examined for the diagnosis of the different kinds of meningitis, for infantile paralysis (acute poliomyelitis), and for syphilis of the nervous system (paresis and tabes). The fluid is obtained by *lumbar puncture* and is allowed to run from the needle directly into sterile test-tubes or centrifuge-tubes. In acute meningitis caused by the meningococcus, pneumococcus, streptococcus, or other organisms, the appearance of the fluid may range from slight cloudiness to thick pus. Smears and cultures are made to determine what bacteria are present.

Cerebrospinal fluid may be clear and yet be very abnormal. In infantile paralysis and syphilis it is usually clear, while in tuberculous meningitis it is either clear or slightly cloudy. If there is a suspicion of tuberculosis, the fluid is injected into a guinea pig. Cultures are not made on fluids from cases of syphilis, but a Wassermann test is carried out.

B. EXPERIMENTS AND DEMONSTRATIONS

Note to Instructor

The following exercises are intended merely as suggestions. It is manifestly impossible to outline a course of exercises that will fulfill the needs of every course. The instructor must adapt the exercises here outlined to his needs. Many of the experiments will prove too elaborate, some will be unavailable because of lack of material. Many experiments will probably suggest themselves to the resourceful instructor which will fit in better with the course being given.

It is suggested that wherever possible the instructor demonstrate the method by actually doing the thing first and then letting the students do it after him. This saves much talk and is a much more effective method than descriptions of methods. One can discuss what he is doing as he works. The students do the work much more quickly after seeing the thing done.

The order of work in the exercises is designed to follow the order in which the material in the text is presented.

Note to Students

Each student should provide herself with a notebook in which she should write up each experiment or demonstration according to a required form. In writing up the exercises the following form may be used:

1. State the purpose of the experiment or demonstration.
2. List the materials used.
3. Give a brief description of what was done. Tell WHY each thing was done.
4. Note the results of each experiment and tell why that result was obtained or what conclusion you can draw from it.

Exercise 1

(*a*) Demonstrate the construction, use and care of the compound microscope.

(*b*) Mix a bit of yeast cake with water, mount on a slide, examine with the high dry lens and draw.

(*c*) Examine and draw a mount of a mold.

(*d*) Examine a hanging drop of a 24 hour old culture of B. subtilis in a hanging drop preparation.

(*e*) Rub a few drops of xylol along the margin of a rabbit's ear. Shave away the hair. Notch the marginal vein with a sharp scalpel and collect two or three cc. of the blood in a test tube. Allow to clot. "Ring" the clot and set in the refrigerator till next time.

(*f*) Make a film of blood from a student's ear or finger, stain with Wright's stain and examine for different kinds of cells. (See appendix Fig. 57.)

Exercise 2

(*a*) Note clot and formation of serum in blood collected last time.

(*b*) For the study of putrefaction, put a piece of lettuce leaf and a bit of raw meat each into a test-tube of water. Incubate. Examine next time.

(*c*) The members of the class should coöperate in the following experiment: Pour 4 plates of agar. Expose one on a table while dusting with a dry duster. Expose another by touching it with the lips. Allow a roach (dipped in a culture of staphylococci) to run over the third plate. Lay a hair (from a head inclined to dandruff) on the fourth. Other experiments of this type will suggest themselves.

(*d*) Make streak cultures on blood agar plates from the throats of some of the students. Demonstrate the method of taking throat cultures properly at this time.

(*e*) Fermentation: Fill 3 fermentation tubes ¾ full of starch suspension, flour suspension and dextrose solution respectively. Add 1 cc. of yeast suspension to each tube. Place the tubes in a water bath at 37° C. Note time and amount of gas formation.

(*f*) Put a small amount of oatmeal or other cooked cereal in 3 sterile Petri dishes. Inoculate with B. prodigiosus. Incubate one dish, refrigerate the other and hold the third at room temperature till next time.

Exercise 3

(*a*) Note results of cultures made last time.

(*b*) Demonstrate method of simple methylene-blue stain and let each use it to stain a broth culture of staphylococci, streptococci, B. subtilis, and one of the vibrios.

(*c*) Repeat (*b*) using the Gram stain.

(*d*) Demonstrate method of examining for motility with hanging drop. (B. subtilis serves well.)

Exercise 4

(*a*) Working in groups of 3 or 4 prepare 500 cc. of extract broth and agar.

(*b*) Demonstrate method of adjusting reaction. Discuss use of indicators and of the various ingredients in the broth.

(*c*) Fish colonies from any available plates showing several kinds of colony.

(*d*) Inoculate a mouse intraperitoneally with pneumococci.

Exercise 5

(*a*) Note results of cultures fished, (pure) and of other experiments.

(*b*) Demonstrate method of autopsying mouse and make smears from peritoneal cavity. Cultures may also be made if desirable.

(*c*) Take four sterile packages, each containing a gauze sponge. Prepare a number of pieces of thread, 1 to 2 inches long; dip them in a broth culture of Bacillus subtilis, and allow to dry. Open the packages with aseptic technic and insert the threads. Bake Package I in the hot-air oven one hour at 150° C. Steam Package II in the Arnold sterilizer for half an hour. Autoclave Package III for twenty minutes under 15 pounds pressure. Use Package IV as a control.

At the end of sterilization put the threads into tubes of sterile broth. Examine at the next session and compare results.

(*d*) Perform the same experiment with Staphylococcus aureus or Bacillus prodigiosus.

(*e*) Dip the points of three pairs of forceps in a broth culture of Bacillus subtilis and allow to dry. Put each pair in a separate pan containing boiling water to which 1 per cent of sodium carbonate has been added. Boil the first pair 30 seconds, the second, one minute and the third, ten minutes. Make cultures at the end of sterilization.

(*f*) Repeat (*e*) with Staphylococcus aureus.

(*g*) Prepare a small jar of string beans for canning. Take water from the jar for culture. Steam the jar in an Arnold sterilizer for one hour on three successive days, making culture after each exposure.

(*h*) To demonstrate the power of steam under pressure, the instructor should perform the following experiment: Put a few drops of water in a test-tube and push a cork lightly into the mouth. Hold the test-tube in the flame a few seconds, using a holder. Keep the test-tube at arm's length and pointing away from the body.

(*i*) Demonstrate the action of a porcelain filter.

Exercise 6

(*a*) Note results of previous experiments.

(*b*) The probationers should be given the Schick test and those who are susceptible immunized with toxin-antitoxin. The class should see the method of making the test, observe the reactions systematically, and help with the immunizing injections.

(*c*) A similar procedure should be carried out with the Dick test and anti-scarlet fever immunization.

Exercise 7

(*a*) The class should become familiar with the sterile outfits for serum injection which are put up by manufacturers. Note the strength of the serum, license number, and return date.

The students should be given special opportunities to observe any cases in which serum treatment is given, and they should hand in written reports, noting the dosage, methods of administration, and effect on the course of the disease.

(*b*) Inject a guinea pig with diphtheria toxin. Inject another pig with toxin and follow with an injection of antitoxin sufficient to protect. Note results next time.

Exercise 8

(*a*) The instructor should show the method of making an autogenous vaccine.

(*b*) The class should observe any vaccine treatment given in the hospital.

(*c*) If it is practicable, the antityphoid inoculation of the probationers should be carried on in connection with this course. The students should help with the vaccinations and afterward observe the inoculated persons systematically, recording the symptoms, and taking the temperatures. The reports should be handed in.

All unvaccinated nurses should be vaccinated. The class should assist in the vaccinations and observe the reactions systematically.

Exercise 9

(*a*) Each member of the class should make a culture from her fingers by passing them over a sterile agar plate. See also Exercise 2, *c*. (Save the plates for Exercise 12, *f*.)

(*b*) Each student should perform the following experiment: Take four sterile agar plates. (1) Breathe quietly a number of times on the surface of the first plate held 6 inches from the face. (2) Repeat the process while talking in an ordinary tone of voice. (3) Cough violently on the surface of the third plate held one foot in front of the mouth. (4) Repeat (3) using a mask. Incubate all plates and examine at the next meeting.

(*c*) The instructor should infect three dishes with Bacillus prodigiosus. The class should then co-operate in carrying out the following experiment: Prepare a panful of slightly soapy, lukewarm water (record temperature). Using a piece of gauze as a dishcloth, wash together in the pan the three infected dishes and three non-infected ones. Drain on paper toweling. Place 2 cc. of sterile broth in one infected and 2 cc. in one non-infected dish. Rinse by rotating the dishes. The instructor will then plate 1 cc. of the broth from each dish. Rinse one infected and one non-infected dish in a panful of the hottest water that will run from the tap (record the temperature). Drain, rinse, and plate as above. Boil the two remaining dishes for five minutes and proceed as above. Plate 1 cc. of water from the dishpan. Rinse the dishcloth in sterile water in a Petri dish. Plate 1 cc. of the water. Incubate the plates and examine at the next meeting.

(*d*) If flies are available, the experiment described in Exercise 2 (roach) should be repeated. Examine a fly with a hand lens.

(*e*) Each member of the class should observe herself for one-half day noting every opportunity for contact infection, both of herself and others, which she finds herself committing; for example, coughing into the open, licking postage stamps, omitting to wash hands, etc. Similarly, she should observe for one-half day the breaks in technic of those persons with whom she comes in contact. The reports should be handed in.

Exercise 10

(*a*) Note results of previous experiments.

(*b*) Each member of the class should make a culture from her lips by touching them to the surface of a sterile agar plate.

(*c*) Cultures from the fingers should be made in the following way: Pour 5 cc. of sterile broth into a sterile Petri dish. Rinse the fingers thoroughly in this broth. Make agar plates of the broth undiluted and diluted 1/10.

(*d*) Make a streak culture from the throat and one from the nose. Examine stained specimens from the swabs. In this connection the nurses should study illustrations, or better, anatomical models of the nasopharynx and of the interior of the nose.

(*e*) Collect several centimeters of saliva in a sterile tube. Make plates of it diluted 1/10 and 1/1000. Examine a stained slide and a hanging drop.

(*f*) Make plates of the following dilutions of feces: 1/10, 1/1000, $\frac{1}{1,000,000}$. Make a stained slide and a hanging drop of the 1/1000 dilution. Draw one field from the stained specimen.

(*g*) Isolate the colon bacillus from one of the plates. Note the odor of the culture. Make a stained slide. (Use Endo or eosin-methylene-blue agar.)

(*h*) Stain smears of scrapings from the tongue and teeth.

Exercise 11

(*a*) Note results of previous experiments.

(*b*) The instructor should demonstrate the method of making a standard plate count of the bacteria in a sample of poor grade milk.

(*c*) Incubate a little milk in a tube until next time.

Exercises 12 and 13

(*a*) Make smears from the milk incubated last time. Look for streptococci.

(*b*) Demonstrate blood agar plates of alpha and beta types of streptococci.

(*c*) Demonstrate agar or Loeffler's serum slants of Staphylococcus albus and Staphylococcus aureus.

(*d*) Demonstrate smears from cases of gonorrhea.

(*e*) Repeat Exercise 2, *d*. (Use blood agar plates—for streptococci.)

(*f*) Repeat Exercise 9, *a*.

(*g*) Disinfect the hands according to the method in use on the wards and plate again.

Incubate the plates and compare them at the next session with those of Exercise 9, *a*.

(*h*) Utilize the cultures previously made from the hands and throats of members of the class for demonstration of Staphylococcus aureus and Streptococci.

(*i*) Get soiled dressings and specimens of pus from the wards and make smears.

(*j*) Examine an unstained specimen of pus with the high dry lens. Note the leucocytes. Make a stained slide; examine for bacteria and draw some leukocytes.

(*k*) Illustrate the stages of an acute infection by the temperature charts of a pneumonia or typhoid case or of any other acute infectious diseases which may be available in the hospital.

(*l*) Show cultures of pneumococci and examine microscopically. If possible, a mouse should previously have been inoculated with scarlet fever sputum, or streptococci. This may be autopsied and plates streaked.

(*m*) Examine a stained slide of any mucopurulent sputum to demonstrate the general composition of sputum (leucocytes, mucus, and bacteria).

(*n*) If possible, show either fresh or Kaiserling specimens of lobar and bronchopneumonia.

(*o*) Show pictures or models of the Eustachian tube and middle ear to illustrate the pathway of infection from the throat to the ear.

Exercises 14 and 15

(*a*) Note results of previous experiments.

(*b*) Inoculate fermentation tubes of lactose and dextrose broth with B. typhosus, B. coli, B. dysenteriæ and one of the paratyphoid bacilli.

(*c*) Examine and make notes on cultures made in Exercise 12 or 13.

(*d*) After incubation of the fermentation tubes, note presence of acid and gas. How distinguish between B. typhosus and B. dysenteriæ?

(*e*) Demonstrate the Widal test.

Exercise 16

(*a*) Demonstrate smears from animals dead of anthrax.

(*b*) Demonstrate smears of cultures of B. anthracis, showing spores.

(*c*) Demonstrate cultures of B. anthracis.

(*d*) Inoculate a guinea pig with tetanus toxin and another with toxin and antitoxin.

(*e*) Inoculate a tube of sterile milk sealed with vaseline and containing a bit of peptone, with B. welchii.

Exercise 17

(*a*) Note cultures and inoculations made last time.

(*b*) Show a culture of the diphtheria bacillus and have the class examine stained specimens. If there are cases of diphtheria in the hospital, cultures from them should be utilized. Cultures should also be taken from the throats, noses, and hands of the nurses who have been caring for the patients.

(*c*) Inoculate several tubes of sterile milk (without litmus) with diphtheria bacilli. Incubate with a sterile control tube. Make cultures from the inoculated tubes; then have the students pasteurize the inoculated tubes by keeping them in the water-bath at 60° C. for thirty minutes. Cool rapidly in cold water and take a culture from each.

Exercise 18

(*a*) Show cultures of the tubercle bacillus.

(*b*) Obtain a positive sputum (from the laboratory of the Health Department if necessary), and demonstrate the method of staining. The class should examine the slides.

(*c*) Show Kaiserling specimens of tuberculosis of the lungs and other organs, or fresh material if available.

(*d*) If a guinea pig is to be inoculated with tuberculous material in the regular course of the laboratory work, or if an infected animal is to be autopsied, it should be demonstrated to the class.

Exercise 19

(*a*) Show stained specimens of the Spirochæta pallida. Through co-operation with the genito-urinary department of the hospital or a Board of Health clinic it may be practicable to demonstrate the living organisms with dark-field illumination. If possible show a culture of the Spirochæta pallida.

(*b*) Demonstrate a Board of Health Wassermann outfit.

Exercise 20

(*a*) Show stained slides of malarial blood and fresh specimens if they should happen to be available.

(*b*) If the class is held at the right season, catch some mosquitoes with a chloroform bottle and examine with a hand lens. A chloroform bottle is prepared as follows: Prepare a cork disc so that it will wedge in the bottom of a small wide-mouth bottle. Saturate the cork with chloroform. Invert the bottle over a resting mosquito.

(*c*) Trypanosomes may often be found in the blood of wild or white rats. These are easily stained with Wright's stain.

(*d*) Yeasts and molds may be demonstrated at this time also. Mount a piece of moldy bread under low power to show spores, hyphæ, etc.

C. GLOSSARY

Agar.—A gelatine-like substance used for cultivating bacteria on its solid surface.

Alpha.—First letter of the Greek alphabet. Used to designate certain types of streptococci.

Aneurysm.—A sack-like dilatation of a blood vessel due to an injury to the wall of the vessel. Usually syphilitic.

Angina.—Sore throat. Any acute pain.

Aniline.—A type of dye or stain. Aniline dyes are those generally spoken of as "coal tar dyes." Made from a byproduct in the manufacture of illuminating gas.

Anterior poliomyelitis.—Infantile paralysis.

Antibody.—A substance produced by the body to neutralize or destroy bacteria or their poisons. The exact chemical nature of antibodies is unknown.

Antidote.—A remedy to counteract the effects of a poison.

Arsphenamine.—A drug containing arsenic used to treat syphilis.

Arthritis.—Inflammation of a joint.

Ascitic fluid.—Serum-like fluid which collects in the abdominal cavity in certain diseases such as cirrhosis of the liver and kidney diseases.

Beta.—Second letter of the Greek alphabet. Used to designate certain types of streptococci.

Bronchi.—Smaller air passages in the lungs—branches of the trachea.

Carbohydrate.—Starches, sugars of various kinds (grape sugar, milk sugar, etc.) and related substances.

Carrier.—One who harbors the germs of a disease although not suffering from the disease himself.

Casein.—The chief protein of milk; the curd.

Cell.—In biology the smallest unit of independent living matter The structural unit of all tissues.

Centrifuge.—A machine for whirling test tubes or flasks. The tubes are held near the top in cups, and when the machine revolves the tubes stand straight out because of the outward "sling." Sediments will settle to the bottom very quickly in such a machine.

Centrifuge tube.—A short, pointed, glass tube used in the centrifuge.

Cerebrospinal fluid.—The fluid surrounding the brain and spinal cord and found in the hollow spaces of the brain and in the canal in the center of the spinal column.

Cervix.—The part of the uterus which projects into the vagina.

Cilia.—Tiny, hair-like projections from bacteria by means of which they move about. Many cells other than bacteria have cilia.

Coal tar.—A byproduct in the manufacture of illuminating gas.

Communicable.—Capable of being transmitted from one person to another.

Conjunctiva.—The covering of the front part of the eye.

Contagious.—Very easily transmitted from person to person by contact.

Cubic centimeter.—The volume of a cube approximately ½ inch on each side.

Cytoplasm.—That part of the cell which is neither cell-wall, nucleus, nor other well defined structure.

Death rate.—The number of deaths occurring each year in proportion to the population. The proportion of deaths from a disease in relation to the total number of cases.

Dextrose.—The sugar that is found in fruits. Glucose.

Element.—Those substances of which all other things are made and which cannot be divided into any other substances. Iron, gold, oxygen, hydrogen, carbon (soot) are examples of elements.

Endocarditis.—Inflammation of the lining of the heart and especially of the valves.

Endo-toxin.—A toxin or poison which remains inside the living cell and is not secreted into the surrounding fluid.

Enteritis.—Inflammation of the intestine.

Enzyme.—A substance of unknown composition, secreted by a cell, which has the power of producing chemical change in certain substances.

Epidemic.—A disease which affects numbers of persons in a certain locality at the same time.

Eruption.—A rash or breaking out on the skin.

Exo-toxin.—A toxin or poison secreted by the living cell into the surrounding fluid.

Fetus.—The unborn child.

Fontanel.—The soft space on the top, front portion of an infant's head.

Gangrenous.—Dead and partly putrified portion of the body.

Gram.—A scientist who devised a certain method of staining bacteria. A unit of weight equal to ½ the weight of a ten cent piece (approximately).

Ground water.—The water which is found in the soil various distances below the surface.

Gynecological.—Related to the branch of medicine which deals with women's diseases and constitution.

Hemolysis.—The destruction of red blood corpuscles with the liberation of the red coloring matter.

Host.—One who harbors a parasite.

Hydrocele.—A collection of fluid especially in the scrotum. It is much like ascitic fluid.

Iliocolitis.—Inflammation of the lower part of the small intestine and the large bowel.

Immunity.—Resistance to disease.

Incineration.—The process of destruction by burning.

Incubate.—To maintain under suitable conditions for growth.

Incubation period (of a communicable disease).—The time elapsing between the date of infection and the appearance of symptoms.

Incubator.—A room or cabinet for maintaining a certain steady temperature.

Infant mortality.—Deaths of children under two years of age.

Infection.—The communication of a disease from one body to another. The disease producing agent (bacteria, etc.).

Infectious.—Caused by a living organism.

Inflammation.—The response of the body to injury of any kind.

Inoculate.—To transfer bacteria to nutrient material so that they may grow. To introduce various substances into the body to produce immunity or infection.

Intraspinal.—Within the spinal canal.

Intravenous.—Within a vein.

Leucocyte.—White blood corpuscle.

Local.—Limited to one part or place.

Lethargic encephalitis.—Sleeping sickness. Not the African sleeping sickness, but that of temperate climates.

Lumbar puncture.—The process of entering the spinal canal by passing a needle between the bony parts of the spinal column.

Lymph gland.—Nodular, filter-like organs in the spaces through which flow the fluids which are not in the blood vessels.

Marasmus.—Wasting of the body or tissues.

Medium.—Any substance used for the cultivation of bacteria.

Meningitis.—Inflammation of the coverings of the brain and spinal cord.

Micro-organism.—Any organism which cannot be seen with the naked eye.

Morphology.—Shape or form. The study of form or structure.

Mortality.—Death rate.

Motile.—Possessing the power of motion.

Mucopurulent.—Composed of mucous and pus.

Mucous membrane.—The lining or covering of various soft or internal parts of the alimentary, respiratory and genito-urinary tracts. Such membranes contain cells which secrete mucous.

Naso-pharynx.—The upper portion of the back of the throat and nose which is hidden by the palates.

Paresis.—Paralysis.

Pathogenic.—Capable of producing disease.

Pathology.—The study of disease or its effects.

Peritonitis.—Inflammation of the lining of the abdominal cavity.

Petri plate.—A round, glass dish, with flat bottom, straight sides and a similar cover.

Phagocyte.—Any cell which has the power of engulfing solid particles as do leucocytes. Leucocytes are one sort of phagocyte.

Pigment.—Coloring matter.

Placenta.—The after birth.

Preventive medicine.—Medical efforts to prevent disease.

Prognosis.—A judgment in advance concerning the probable outcome of a disease.

Prophylactic.—Preventive.

Protein.—Protoplasm not in living or cellular form.

Protoplasm.—The substance of which all living matter is composed.

Ptomaine.—Poisons produced by the action of bacteria on proteins. Cause gastric disturbances. It is now thought that ptomaines do not really exist but that the disturbances formerly thought due to them are due to other causes.

Public health.—The aspects of health and disease which affect the community as a whole, or in which the community has an interest or responsibility.

Puerperal.—Following childbirth.

Pyogenic.—Causing the formation of pus.

Quarantine.—The isolation of infected person or persons suspected of being infected from all intercourse with non-infected persons.

Respiratory tract.—All the structures concerned in breathing.

Sanitation.—The science and art of maintaining a healthful environment.

Saprophytic.—Causing decay. Living only on dead matter. Not attacking the living.

Seepage.—Soaking through.

Septicemia.—Presence of pathogenic bacteria in the circulating blood.

Serum.—Fluid portion of the blood after formation of the clot.

Specific.—Having an effect on only one disease or germ.

Sterility.—Incapability of producing young.

Suppuration.—Formation of pus.

Susceptible.—Liable to become affected by a disease.

Suspension.—A liquid containing particles of fluid, solid or gas not dissolved.

Tissue.—A group of cells of the same kind all performing the same function. (Muscle, liver, spleen, etc.)

Toxin.—A poison formed by a living organism.

Trachea.—The air passage from throat to lungs. The "windpipe."

Venereal.—Diseases transmitted by sexual intercourse.

Veterinarian.—One skilled in the diseases of animals.

Virus.—A living thing or substance causing disease. Usually thought of as invisible.

Virulence.—Ability to produce disease.

Viscous.—Thick, stringy, slimy, like mucous or cold molasses.

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